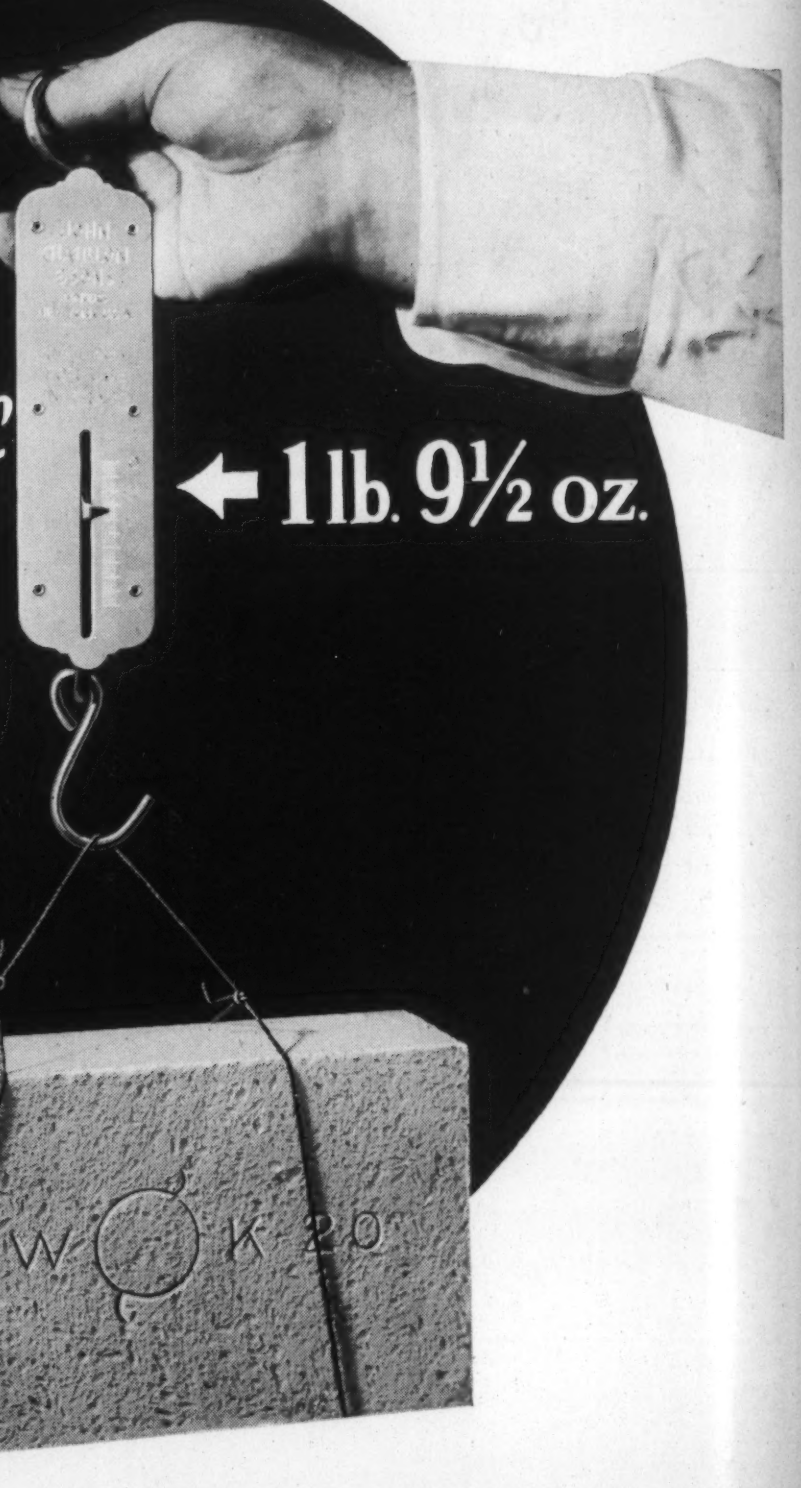
Metals and Alloys

THE MAGAZINE OF METALLURGICAL ENGINEERING

PRODUCTION • FABRICATION • TREATMENT • APPLICATION

FEBRUARY 1941

A simple way to measure the Economy of INSULATING FIREBRICK



The relation between weight and economy of insulating firebrick is explained in detail in a new bulletin—R-2-G — copy on request.

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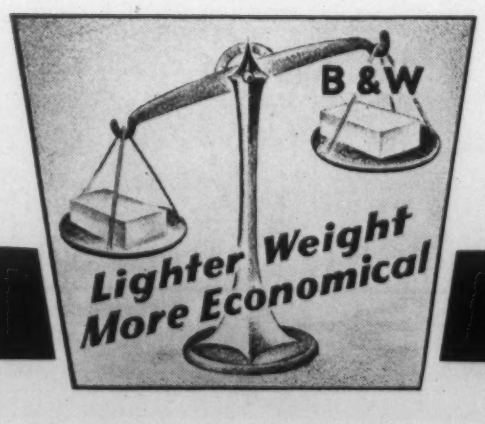

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Metals and Alloys

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Articles

Die Castings in Magnesium Alloy 145
HERBERT CHASE

Two Complex Copper-Cobalt-Silicide Alloys 151
F. R. HENSEL, E. I. LARSEN AND E. F. HOLT

Producing Cast Iron Pipe Centrifugally 155
EDWIN F. CONE AND DON GRAF

Practical Metallography of the Stainless Steels—II ... 162
STANLEY P. WATKINS

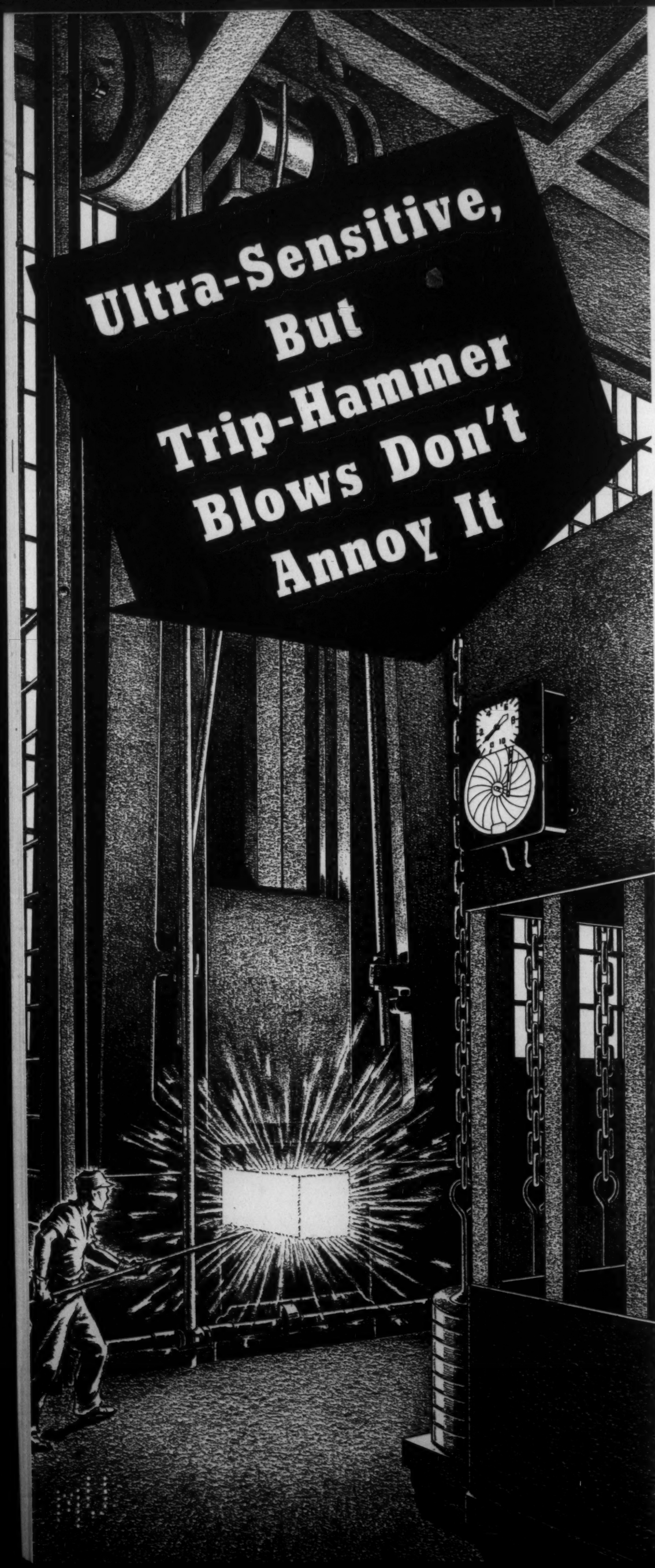
Corrosion Fatigue of Notched Specimens—Class 40 Cast Iron 169
H. W. RUSSELL AND J. G. LOWTHER

A Holder for Metallographic Specimens During Polishing 171
GEORGE R. KAUFFMAN

A. I. M. E. Convention 123
Manufacturers' Literature 128
Highlights 139
Editorial 141
Letters to the Editor 173
News 177
Shop Notes 181
Books 238
Advertisers in This Issue 244
Trends 246

Metallurgical Engineering Digest

Production 188
Processing and Fabrication 194
Properties and Applications 218
Testing and Control 230



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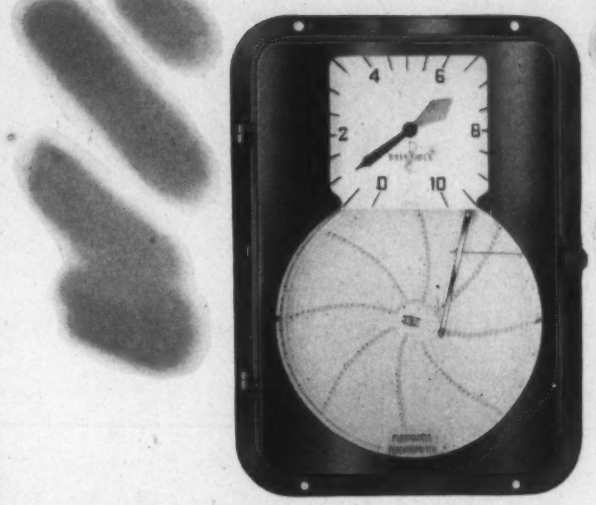

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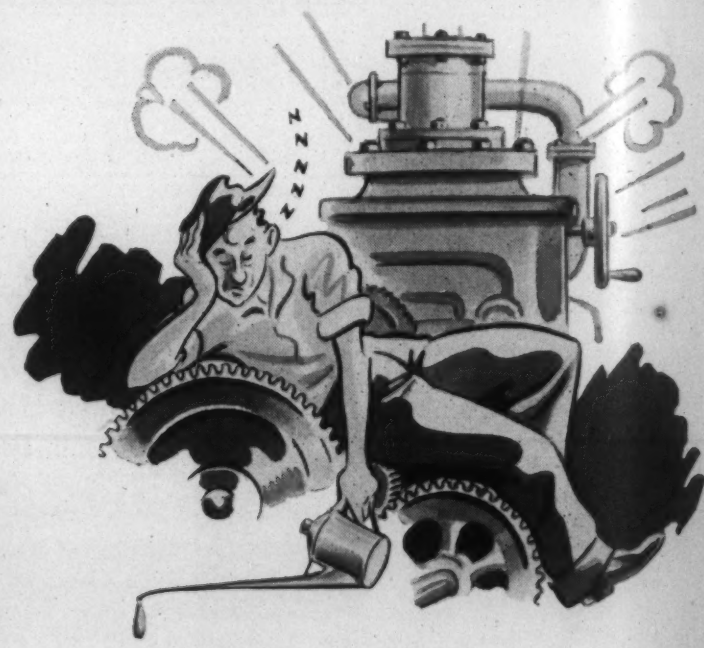

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Feature Section

Magnesium Die Castings

Several phases of this subject are discussed authoritatively by Mr. Chase. The metal magnesium and its alloys are very much in the public consciousness. This article adds to the general fund of knowledge.

Age Hardening Alloys

The authors, skilled in this particular field, give the results of a research on the effect of beryllium and phosphorus added to two age-hardening copper-cobalt-silicide alloys.

Cast Iron Pipe Centrifugally Cast

One of the present-day methods of producing cast iron pipe by the centrifugal process is presented pictorially. A few brief historical facts are included.

Metallography of Stainless Steels

This is the second instalment of Mr. Watkins's discussion commenced in the January issue. A feature is the illustrations which illumine the presentation.

Corrosion Fatigue of Cast Irons

Discussing various phases of the notch effects in fatigue of different grades of cast iron, the authors state that high test cast irons have engineering virtues with which they are seldom credited.

A Unique Holder

A special holder for specimens of metals for microscopic examination is described and recommended by Mr. Kauffman.

Scrap in the Blast Furnace

There is nothing inherently wrong with using scrap as part of the blast-furnace charge, says Edwards (page 188), who recounts experience in producing pig iron from burdens containing up to 100% steel scrap. The iron so produced, given suitable control, was as good for high-quality steelmaking as was that made without scrap.

Engineering Digests

Resistance Brazing

Brazing by passing electric current directly through the parts to be joined and the brazing alloy between them is described by Wensley (page 196).

Atmospheres

The word "atmospheres" is being pushed around semantically about as much as the word "time," which is variously made, found, told, kept, saved, served and killed. One kind of "atmosphere" is sought by drawing-room decorators; another, more tangible variety is the characteristic personal property of the unbathed stableboy; and the most valuable type is the stuff of the air we breath. The atmospheres of professional interest to metallurgical engineers, however, are not glamorous, but inert; not annoying, but protective; and not ubiquitous, but controlled. A review of recent developments and present practice with them starts on page 198.

Galvanizing Quality

The effects of basis metal composition on the adherence, quality and appearance of hot-dip galvanized coatings are complicated. Sandelin (page 208) in the 1940 Wire Association medal award paper, attempts to untangle them.

Bright Plating

Every process eliminated in the manufacture of a product brings delight to the hearts of both the engineer and executive. Bright plating, which provides lustrous coatings without subsequent buffing, is therefore increasing in popularity, and present practice is reviewed in a composite on page 212.

New Cars and their Metallurgical Design

The importance of the metallurgical engineer in building increased speed, greater comfort, better durability and safety, and even esthetic appeal, into the modern automobile, is evident from a composite on new-car design that starts on page 218.

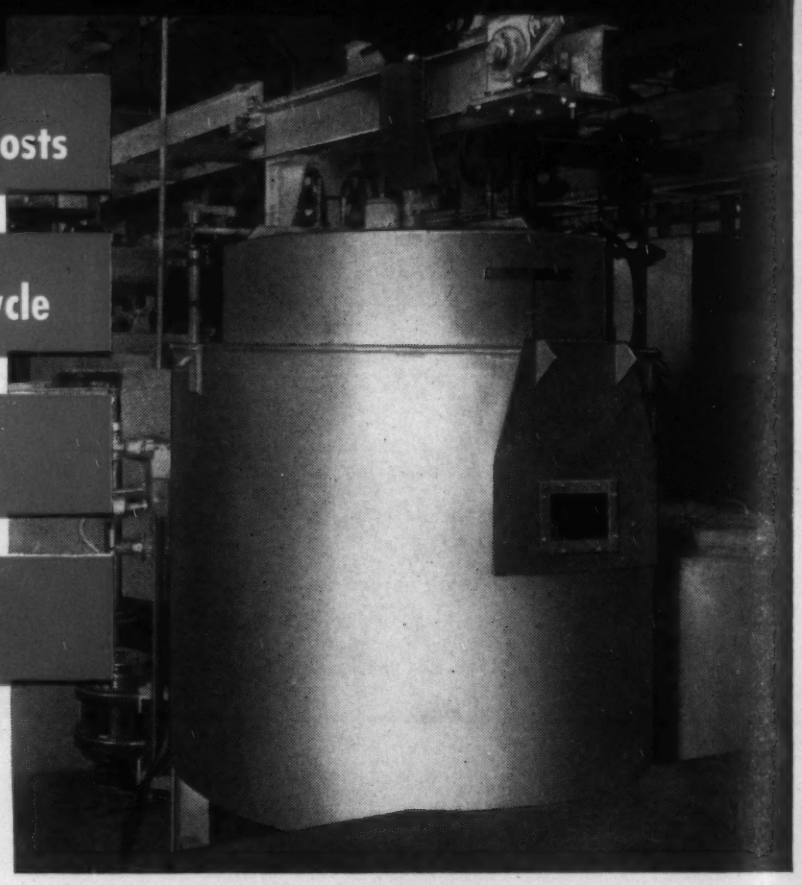
NEW G-E Gas-carburizing Furnace Gives You 4 Big Savings

Saves By Greatly Reducing Carburizing Costs

Saves Time by Shortening Carburizing Cycle

Saves By Completely Eliminating Packing

Saves By Doing Highly Uniform Work



A typical installation of a G-E gas-carburizing furnace. Note the controlled-atmosphere cooling chamber at extreme right, also the easy accessibility of the standard induction motor which drives the fan.

REMARKABLE savings are made with this new gas-carburizing, electric furnace. And the reason is very simple. NO PACKING MATERIAL IS USED. This means that considerably less time is required to bring the charge to carburizing temperature; hence, big savings are made in time and power cost. It also means no labor and no expense for packing parts. Work is simply placed in lightweight trays that are economical to use, and it is ready to be put into the furnace.

But these are not the only savings you make! The high uniformity of work produced by this furnace means that rejects are practically eliminated. Accurate automatic control enables the operator to reproduce any desired treatment at any time, with great accuracy and precision.

Low-cost Gas Provides a Controllable, Uniform Source of Carbon

Propane gas of uniform chemical composition is circulated throughout the charge by a motor-driven fan. The amount of carbon in the furnace is closely controlled by measured regulation of the flow of gas. Tests show that a case of uniform thickness forms on every surface in the charge, regardless of position in the load.

This Free Bulletin May Show You How to Save Time and Money

Our new bulletin, GEA-3523, gives complete information about this new gas-carburizing furnace. The G-E office in your region will be glad to give you a copy. Or, write to General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

The Cabots Speak only to Cabots

No comment on the technique of industrial development is more true than the one by Kettering, that two hens can't hatch a setting of eggs in less than three weeks. There is a time factor in orderly and economic development which cannot be canceled out entirely. Feverish activity in the effort to speed up, or allocating an over-large group to rushing a development, results in waste motion and stepping on each other's feet instead of breaking and following the correct trail.

In the production man's language, there are "bugs" in every new scheme that have to be eliminated before putting the scheme into large scale use becomes the straight engineering problem of merely enlarging a pilot plant or duplicating production units that are already working. For this reason, the "new" developments in industry or in defense measures must always rest on past research that has been quite thoroughly ripened.

It often happens that past research in apparently unrelated fields has brought matters to a degree of ripeness quite unsuspected by those whose information is limited to a single field, so that conditions are ready for an engineering interweaving of known, but not widely known facts. In such case a periodic examination of needs in one field, in the light of information available in others, may greatly speed up the cultivation of seed that would otherwise long lie unsprouted.

The degree to which information has extended is often amazing. This degree is sometimes obscured by the jargon in which expert talks to other experts in his own line, so that others can find out only with difficulty what these experts do know. We glance over each issue of *Electrical Engineering*, and the *Journal of Applied Mechanics* to find pages and pages of mathematical symbols, whose import we have to take on faith. The matters discussed in *Electronics* are almost equally obscure, and even *Photo Technique* contains much that is over the heads of the vast army of amateur photographers.

We appreciate the diminishing number of interruptions of electric service and may grasp the fact that part of this is due to fewer turbine outages resulting from reduction of blade failures through studies of vibration. We see the electric eye and various electronic control devices applied to industrial uses, as well as sense that radio and television are advancing. We buy film that gives better black and white tone rendition and if we like, we can take color photos, without necessarily understanding the principles involved. We can take it on faith that the articles couched in expert-to-expert jargon promise other practical advances for the future.

In the metallurgical field there are sub-divisions being tilled, sometimes by few, always by few at the start, perhaps later by many when the commercial implications have become evident, in which advances are proceeding too fast to be clearly sensed by those not directly concerned. One field in which information and its application have been advancing by leaps and bounds is controlled atmospheres for heat treating. Another is that of surface finish and its relation to bearings and other mating parts. These have not yet gotten to the point where they have technical societies of their own, but unless the topic falls definitely enough within the bounds of an existing society, a separate one tends to spring up—the Society of Rheology is an example.

A field of metallurgical engineering that has had a long and steady growth, a good deal of which is traceable to the influence of its special society, is welding. Less than 20 years ago this was a small and struggling group. We remember when welding was so much of an art that the engineer put no faith in the integrity of a weld, and classified welds as about on a par with soldered joints in respect to load-carrying ability. A few people, like S. W. (Sound Weld) Miller, had the vision and faith to believe that welding could become a science even though some types of welding might long remain an art.

How far welding has advanced since those days is evidenced by the Annual Report of the Welding Research Committee in the December 1940 *Journal* of the American Welding Society. An imposing array of achievement is recorded. Summaries of known fact and opinion, along correlated abstract lines, have been published, as has been much original research, both fundamental and practical. Much more is under way, the list of topics being all-embracing. Some of this work is obviously of a side-issue type, where a professor allocates a topic to a graduate student and neither the professor nor the student has time to do a real job, so that the primary object of much of this effort must be psychological rather than technological, i.e., aimed to make budding engineers weld-minded.

A good deal of the work, however, is on a scale that gives promise of technical results. One of the most interesting projects is that on spot-welding of aluminum and magnesium alloys, to the tune of $27,500, supplied by Wright Field, the Navy Bureau of Aeronautics, the National Advisory Comm.

(*Continued on page 173*)

- ✓ TURNING
- ✓ BORING
- ✓ DRILLING
- ✓ MILLING
- ✓ HOBBING
- ✓ REAMING
- ✓ THREADING
- ✓ BROACHING

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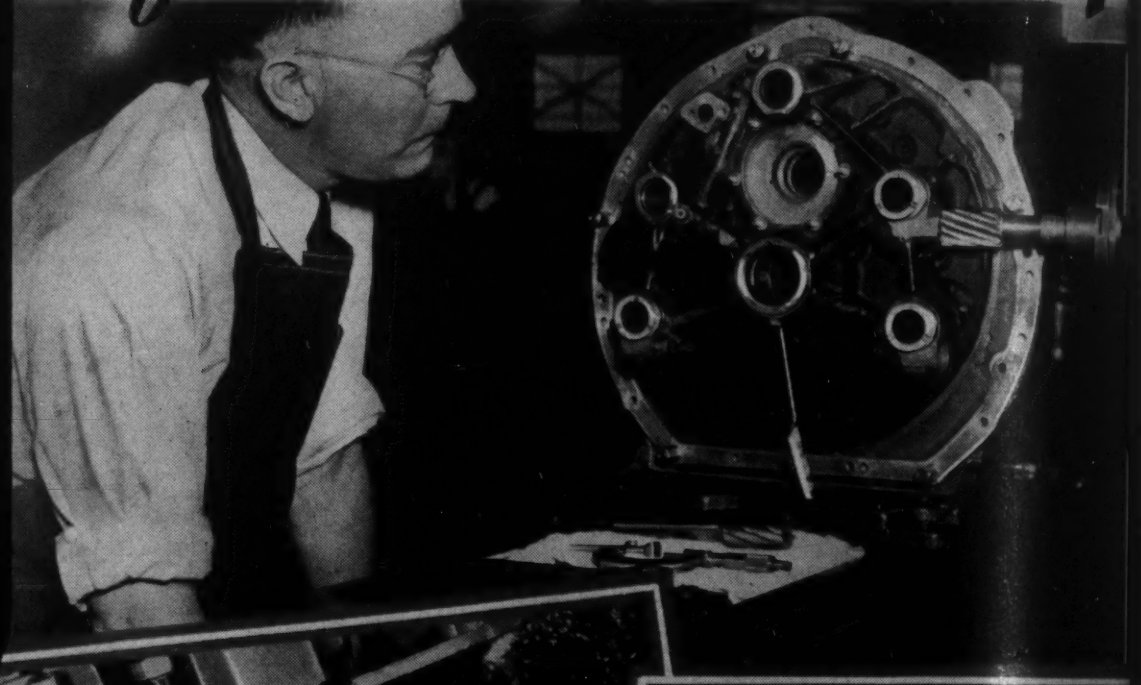

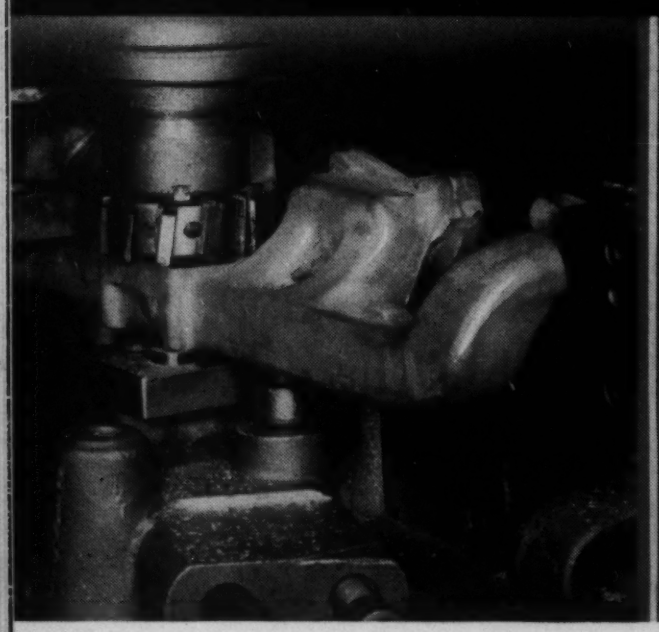

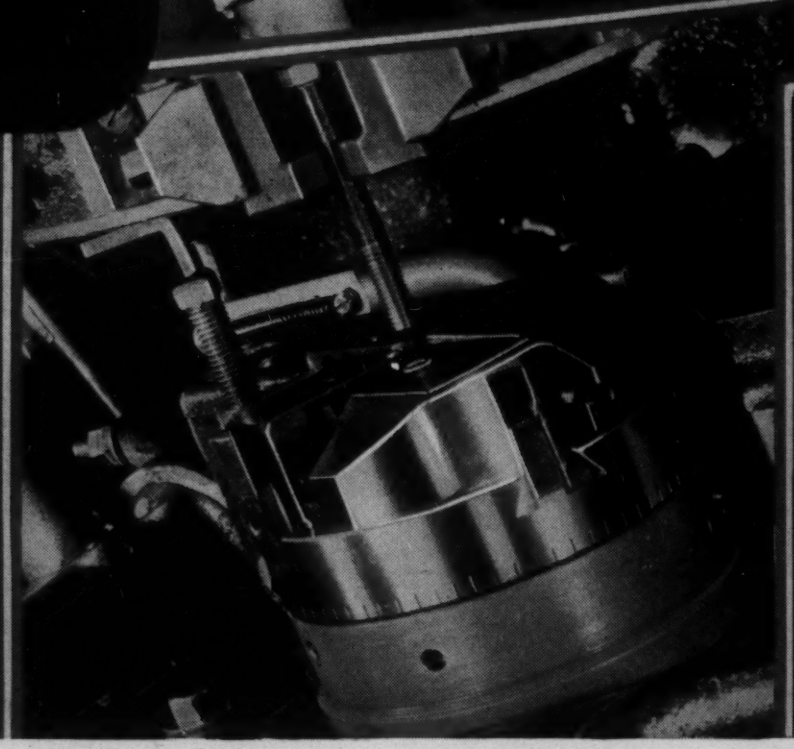

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Die Castings in Magnesium Alloy

Magnesium is very much in the metallurgical engineering picture—the metal and its alloys have been forging to the front very rapidly, so that information on developments in this field is eagerly read.

From the pen of an author who is thoroughly posted on die castings in general and on other products, we present this article written at our request. Mr. Chase discusses many phases of the subject—die casting machines, oxidation of the molten metal, dies used and their life, properties of some of the alloys, corrosion and its prevention, and some of the uses.—The Editors.

BY HERBERT CHASE

PRESENT INDICATIONS POINT to the likely substitution of die castings in magnesium alloy for many parts heretofore die cast in aluminum alloy and to the use of many more magnesium die castings for parts newly designed for the purpose. An important reason for this is the lighter weight of the magnesium alloy.

It is not in any sense to be inferred that aluminum alloy die castings are not satisfactory, for they have long since demonstrated their utility. In a large proportion of cases, however, aluminum alloy is chosen (as compared with heavier and less expensive alloys) largely or only because of its lighter weight, and, since magnesium alloy is still lighter by about one third, it has a further advantage on this score.

Strength and other physical properties of the two alloys are similar or nearly the same, but difficulties in die casting magnesium alloy, now largely overcome, have delayed its wider use. Today, in the case of some parts, it is possible to purchase magnesium alloy die castings at the same price *per casting*, as if they were produced in aluminum alloy. In other words, the higher price per pound of magnesium is offset by the lower weight per casting.

Cold Chamber vs Gooseneck Machines

Some magnesium alloy die castings have been produced experimentally in so-called "gooseneck" machines in which air under about 400 lbs. per sq. in. pressure injects the metal into the die. Most aluminum alloy die castings are still produced on such machines, usually with good results, but with magnesium it proved difficult to protect the metal against rapid oxidation at the high temperature it was necessary to use. Much better results have been secured with so-called "cold chamber" die casting machines which depend on an entirely separate melting pot and make use of far higher pressures. In employing such machines (some of which are used also for aluminum alloys and also for die casting brass and other copper-base metals) the metal is kept at or slightly above its melting point in a separate melting pot and is ladled into the "cold chamber" of the machine by hand. The amount ladled at each "shot," or die filling, is slightly more than enough to fill the main die cavity, leaving a slug of excess metal which is ejected with the casting, and which makes it unnecessary to measure the charge more closely than is convenient.

A great advantage of the cold chamber machine is that, when properly proportioned, pressures of 4,000 lbs. per. sq. in. or higher can be applied to the metal. This insures a dense casting and one which has proved to have physical properties superior to those obtained in castings made in gooseneck machines. Even more important, in the case of magnesium die castings, is that the separate metal pot makes it easier to protect the molten metal from oxidation except during the short ladling operation, when the metal is exposed to the air. It is possible, however, to avoid any detrimental effects from this short exposure and also to avoid contaminating the casting with flux or dross.

Preventing Oxidation

As in other casting with magnesium alloy, it is necessary to keep the metal in the melting pot covered to minimize contact with air. This is done by pro-

viding the metal pot with a dome in which sulphur is melted and from which sulphur fumes issue. The fumes burn and introduce sulphur dioxide to form a "blanket" above the molten metal, which is thus kept from oxidizing. In some cases, added protection is given by throwing a small amount of "Dow Agent No. 14" (a mixture of sulphur, boric acid and ammonium silicon fluoride) under the cover. Sulphur from the dome burns at holes around the ladle opening and any excess fumes are drawn off through a hood which covers the dome.

Because of the high pressure applied to the metal during and immmediately following its injection into the die, it is necessary to apply a heavy locking pressure to the die to prevent the halves of the die from opening slightly under the high internal pressure. This not only avoids spitting of molten metal but reduces the flash formed at the die parting. Some of the machines used employ direct hydraulic pressure for locking and others apply hydraulic pressure through a toggle mechanism for locking. In all cases, the ram for metal injection is operated hydraulically.

Aside from the precautions taken in avoiding oxidation of the molten metal, the process is much the same as that employed in die casting aluminum and copper-base alloys in cold chamber machines. Casting temperatures are about the same as for aluminum and the same dies can be used, except, perhaps, for slight changes in gating and venting. Casting temperatures are lower than for copper base alloys and, in consequence, there is less tendency for die surfaces to check. Die life is correspondingly longer and dies require less redressing. Castings can be made as smooth as those in aluminum alloy. The pouring temperature ranges from about 1175 to 1250 deg. F., as a rule, but may have to be 1300 deg. F., in some instances. Die temperatures are reported as running from 250 to 500 deg. F., with 350 deg. F., a good average and it is said to be unnecessary to apply water cooling except for unusually high production.

Dies Used

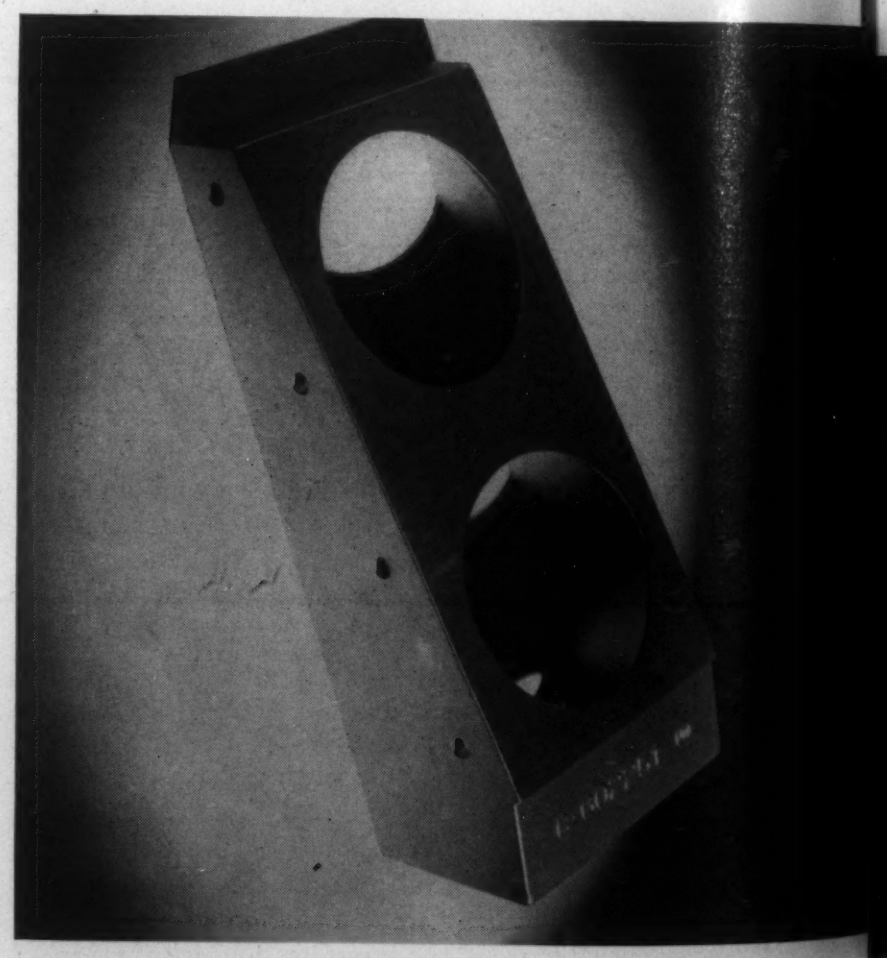
Although carbon tool steels can be used for dies required only for short runs, much longer life results if tool steels of the type containing 5 per cent Cr and 6 per cent W are used. The dies are drawn at 1000 to 1100 deg. F. to give about 450 Brinell hardness. As dies usually become coated with a thin oxide film, other coating is said to be unnecessary. Too high a die temperature may cause excessive oxidation of die surfaces and result in rougher surfaces on castings.

It is recommended that scrap from castings be not remelted for die casting directly, but that this metal be refined by the open pot method, using a large quantity of flux such as Dow No. 23A. Three-pound ingots cast from the refined metal may be remelted with virgin ingots for die casting. Casting efficiency is said to average about 95 per cent and over-all metal efficiency about 90 per cent for medium to large size castings. Casting efficiencies may be higher if castings have wall thicknesses of 3/32 in. or greater.

According to one authority, (Dow Chemical Co., to which the author is indebted for much of the information used in this article) there is little or no gain in casting at pressures above 4,000 lbs. per sq. in. and some satisfactory castings are produced at much lower pressures, but much depends on die design, casting design, alloy used and other factors. Castings have been made with walls as thin as 0.040 in. over small areas but 0.050 in. is considered a more practical minimum, even in small castings. This commonly has to be increased as the size of the casting and the extent of thin areas thereof are increased. Castings up to about 6 lbs. in weight are considered practical and at least one having a length of 74 in. has been produced.

Properties of Mg Alloys

An accompanying Table containing data supplied by the Dow Chemical Co. gives the physical properties and characteristics of the various magnesium



Die cast magnesium alloy housing for a portable instrument used in the mining industry.

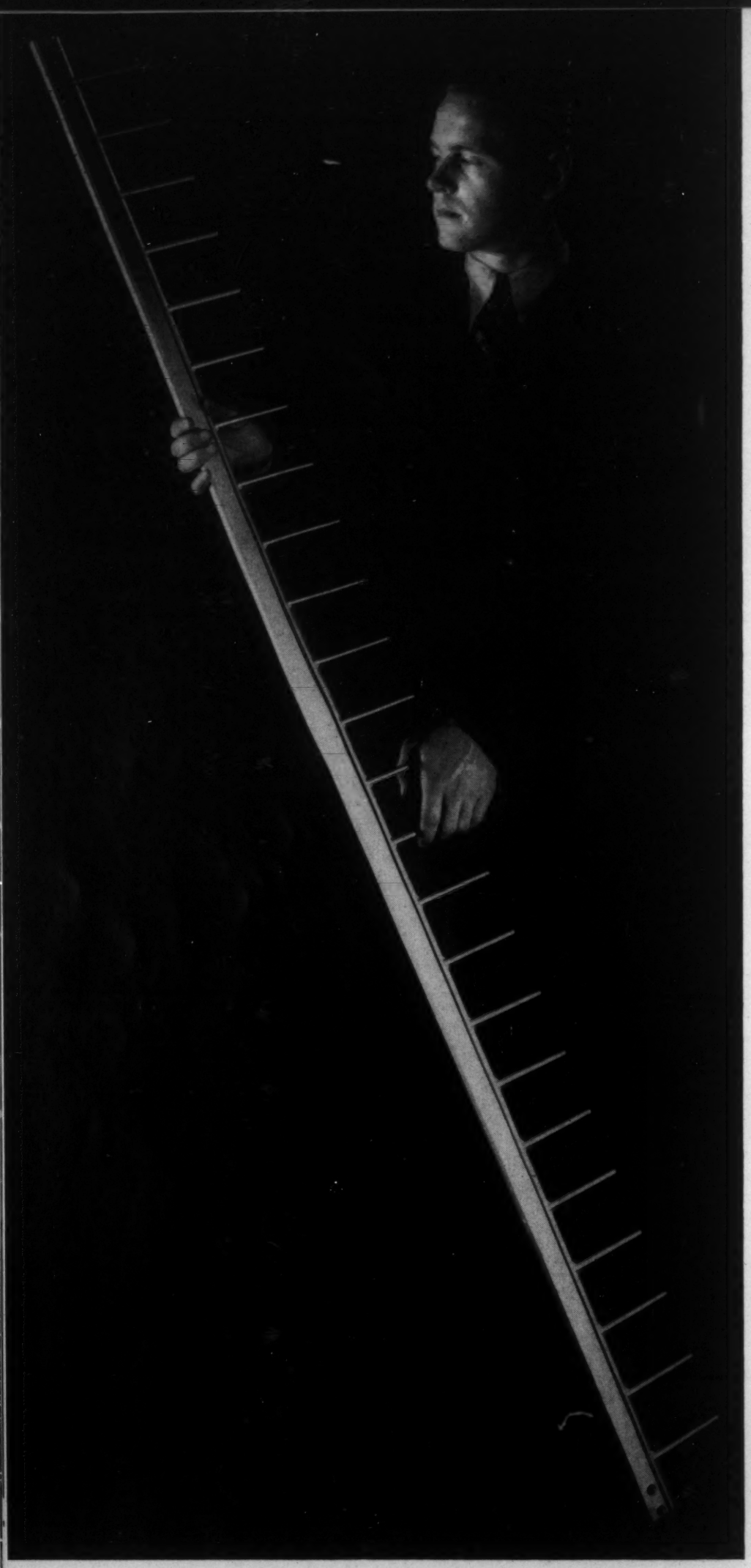
View of high pressure "cold chamber" die casting machine used for magnesium alloys in the plant of the Dow Chemical Co.

Thin wall and remarkably light die casting in magnesium alloy used as a housing for a portable business machine.

alloys employed for die castings, some of which are marketed or used by other companies under different designations. As will be seen, the alloys contain from 6 to 10 per cent Al, all but fractional percentages of the remainder being magnesium. Surface quality and soundness of castings are said to be unaffected by the composition within the limits given, but castability is in the order listed except that the first two are about equal in this respect. Although the first three alloys listed can be solution heat treated with increased ductility and some reduction in yield strength, a better way of increasing ductility is to decrease the aluminum content, as in the fourth alloy listed. This is because sub-surface porosity, which is not eliminated even in the relatively sound die castings produced under high pressure, results in surface blistering if temperatures be raised in heat treatment to 700 deg. F.

Tarnishing and Corrosion

Magnesium die castings are subject to tarnishing and corrosion, especially when subjected to moist atmospheres and tropical temperatures and eventually roughen as a result of the formation of oxide or hydroxide films. For this reason, and also to promote the adherence of organic and/or synthetic



This Dowmetal die casting for a conveyor is 74 in. in length.

finishes, castings are commonly given a chrome pickle. This may be applied by the die caster or, if the purchaser is to machine the casting, by the purchaser subsequent to machining. This pickle involves a five-second dip at 120 deg. F. in a solution containing, per gallon, 1½ lb. of sodium dichromate and 1½ pints of concentrated nitric acid. The result is a slight etch and the formation of a film having a considerable degree of corrosion resistance, even to salt water.

Alternatives include the use of a special air-drying primer or of a baking paint on the untreated metal (both especially developed for magnesium) and intended chiefly for castings to be used indoors. In general, it is recommended that the pickle precede the application of finishes of the paint, enamel and lacquer type and there are many such finishes suitable for use over the pickle finish.

For exposures to marine atmospheres and for other special sets of conditions, various other chemical treatments are recommended, certain of them meeting Army and Navy Air Corps specifications. Some treatments produce oxide or hydroxide coatings which, though dense, hard and adherent, can be dyed in attractive colors and have high abrasion resistance.

Until recently, the electroplating of magnesium alloys had not been considered practical, but success is reported as a result of long experimental work in this field and nickel plating is understood to be now emerging from the laboratory into commercial applications under patent restrictions.

Although die castings in magnesium alloy have been in moderately extensive commercial use for several years, the number of die casters having the required experience in and equipment for their production is still quite limited. Certain hazards are involved in production. It is also considered desirable if not essential to segregate or isolate the production from that of other die castings, partly to avoid the possible mixing of aluminum and magnesium scrap from castings and thereby to aid in

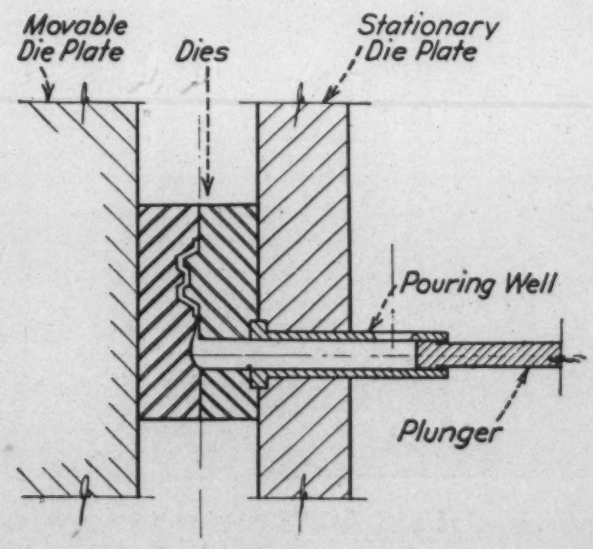
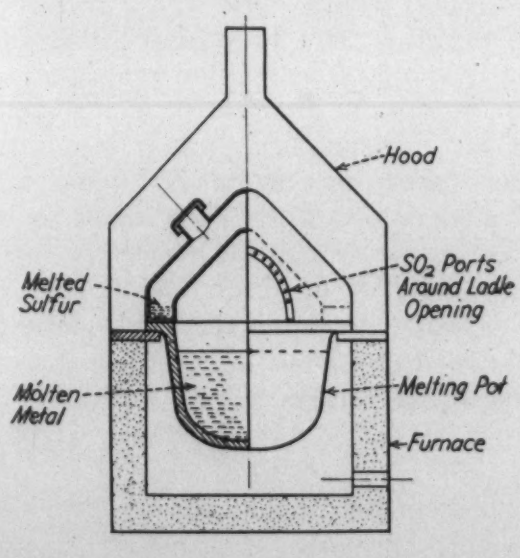


Diagram showing arrangement of dies and injection plunger in a "cold chamber" machine for die casting magnesium alloy. Molten alloy is poured into the well in measured amounts by a hand ladle, after which the plunger or ram is immediately advanced under heavy hydraulic pressure, forcing the metal into the die cavity.

A few of the numerous magnesium alloy die castings supplied for use in aircraft.

Arrangement of the melting pot, showing the dome in which sulphur is melted and ladle opening with holes from which sulphur fumes are discharged and burn to SO_2 which protects the molten magnesium alloy from oxidation.

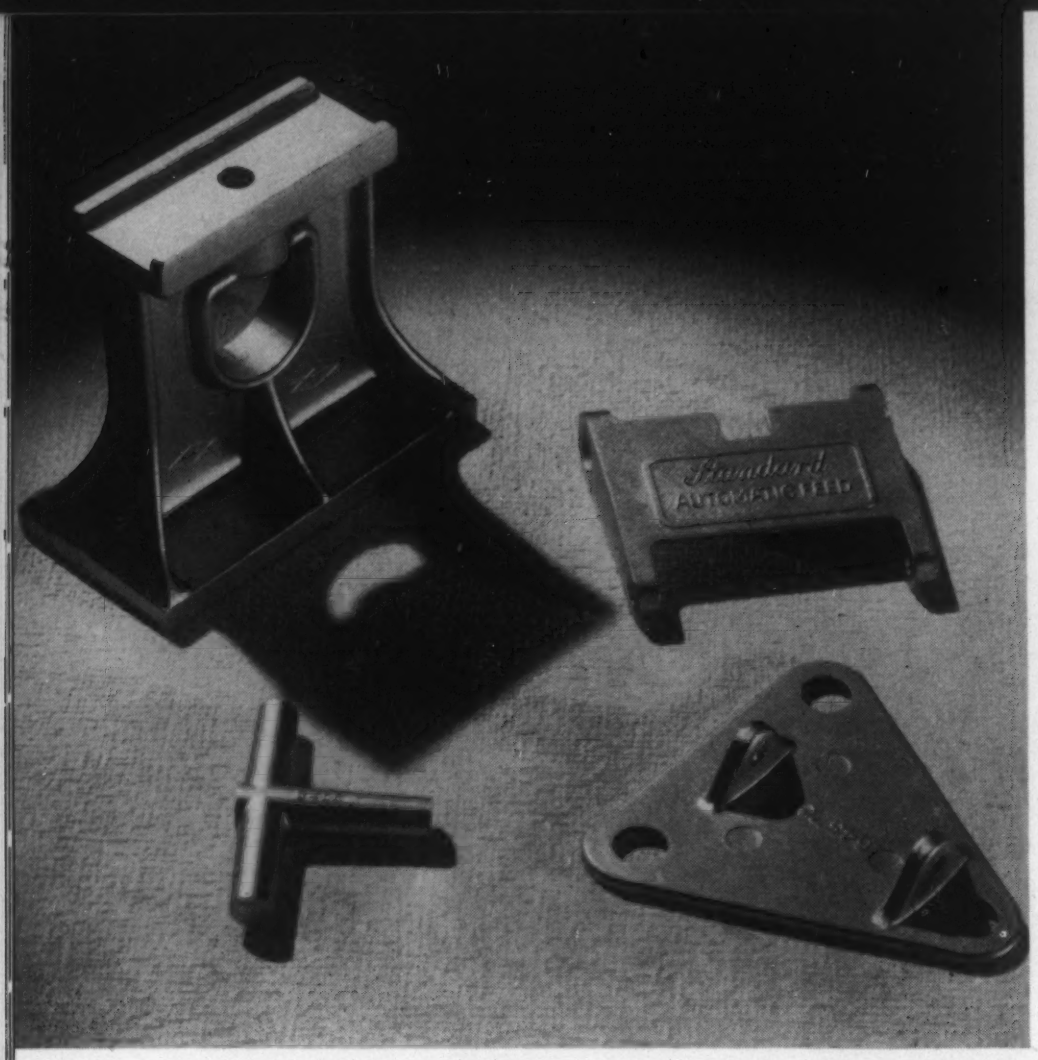


maintaining the desired analysis without introducing the need for continuous checking of analysis. Nevertheless, the production of magnesium alloy die castings has increased rapidly and is attaining, or seems likely to attain, proportions which may rival the production of those aluminum alloy die castings which must be made at pressures above those attained in gooseneck (air injection) machines.

Uses

Since lightest weight is the outstanding characteristic of magnesium alloy die castings, they have naturally been chosen chiefly where lowest weight is required or is highly desirable. A great many such die castings find their way into aircraft but, as the production of aircraft is well below that of certain other products in which magnesium alloy die castings are used, the total number of such castings used outside of aircraft is greater than of those for aircraft.

The largest single use of die castings in magnesium alloy is for generator and starting motor end bells on Ford cars, accounting for some 6000 such castings



Machine parts all of which are light magnesium alloy die castings.

Table of Physical Properties and Nominal Compositions of Magnesium Alloy Die Castings

A.S.T.M. Number....	12	13	....	....
Dowmetal designation	K	R	AX	EX
Nominal composition (per cent)				
Aluminum	10.0	9.0	8.0	6.0
Manganese	0.13	0.13	0.15	0.2
Silicon	0.5	....	0.3	0.2
Zinc	....	0.60	....	....
Magnesium	Remainder	Remainder	Remainder	Remainder
Tensile strength, lbs. per sq. in.....	30,000	33,000	32,000	27,000
Yield strength,* lbs. per sq. in.....	22,000	21,000	20,000	17,000
Elongation in 2 in., per cent	1	3	3	4
Brinell hardness.....	62	60	60	50
Charpy impact strength, ft.-lbs.....	1	2	2	3
Characteristics and uses	Highest yield strength but being replaced by Dowmetal R	Best die casting alloy. Good casting characteristics with high mechanical properties and good corrosion resistance	Largely replaced by Dowmetal R	Used where maximum toughness is desired

* Yield strength is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line.

Physical properties are typical and are as obtained on standard A.S.T.M. die cast specimens.

a day. As these are small castings, the weight saving over aluminum (formerly used exclusively and still used for part of the total requirements) is not large. But Ford is gathering data on the large-scale use of these castings and may well find a more extensive use for them. In any event, the continued use of magnesium alloy for these parts indicates that they have given satisfactory performance.

Other uses, some of which are illustrated, include parts for business machines, especially portable types, including typewriters; parts for electrical appliances and portable electric tools and parts for other products in which light weight and/or low inertia forces are advantageous. Cameras, binoculars and other portable instruments as well as certain tools in which other metals would add undesirable weight, make good use of magnesium alloy die cast parts. Indications point to further use along these and other lines, particularly where the high strength-weight ratio is of special advantage.

Design and Machining

The design of die castings in magnesium alloy is generally similar to that in other alloys suitable for die casting. Dimensional limits which can be held are substantially the same as for aluminum alloys and are only a little wider than for the alloys of lower melting point. Thus, the tolerance as between points in solid parts of the die is plus or minus 0.0015 in. per in. Somewhat thinner sections can be die cast in zinc alloy, but the number of castings calling for unusually thin sections is not very large. Fillets at interior corners are desirable, as in all castings, and suitable drafts must be allowed for cores and on side walls to facilitate removal from the die.

Machining of magnesium alloy die castings is readily done, as the metal machines freely. As fine chips are readily ignited, however, it is recommended that an oil-type coolant be employed, especially as its use may also contribute to the smoothness of cut and may increase the allowable machining speed.

From the foregoing it is readily seen that the magnesium alloy die casting is finding a well merited place in industry. There seems to be no doubt that its use will extend rapidly as engineers are made aware of its merits and become better acquainted with its possibilities and performance under the widening range of conditions for which it is being found suitable.

Two Complex Copper-Cobalt-Silicide Alloys

by F. R. Hensel, E. I. Larsen and E. F. Holt

P. R. Mallory & Co., Inc., Indianapolis, Ind.

THE USE OF COBALT SILICIDE as an age-hardening ingredient in copper has resulted in an alloy, which in the wrought condition has rather unusual properties, both electrical and physical. The present article is a résumé of tests carried out on two copper-cobalt-silicide alloys, to which were added beryllium in one case and phosphorus in the other, to investigate the combined effects of cobalt silicide and cobalt beryllide, and cobalt silicide and cobalt phosphide.

The Alloys

The two alloys investigated had the following compositions (by analysis).

	Alloy A	Alloy B
Copper	96.44	96.03
Cobalt	2.66	2.69
Silicon	0.33	0.40
Cadmium	0.08	0.53
Iron	0.04	0.06
Beryllium	0.43	...
Phosphorus	...	0.31

Test Material

The test material was in the form of 1-in. dia. rods selected from production runs and processed by hot rolling and drawing.

To determine the age-hardening behavior of the alloys as a function of both quenching and aging temperatures, the following sequence of treatments was given both alloys.

A. Water quenched from 900, 950, and 1000 deg. C.
B. Cold worked various percentages after quenching.
C. Aged at temperatures of 400, 450, and 500 deg. C. for various time intervals.

The curves show graphically the detailed "case histories" of the alloys.

Table of Effect of Quenching Temperature and Aging Temperature on Hardness

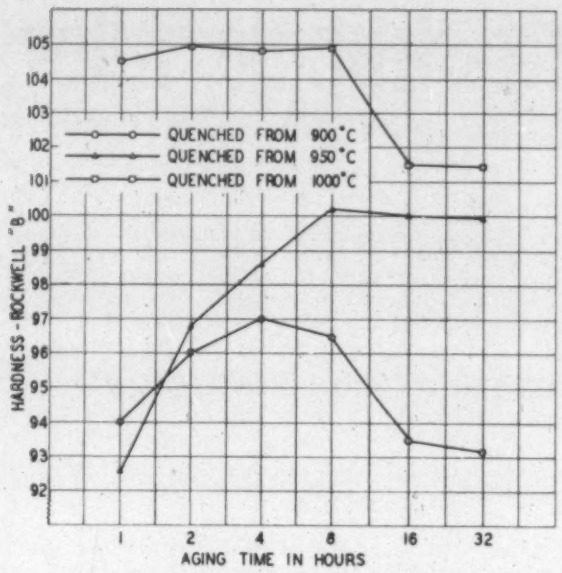
Curve No.	Ordinates	Condition of Samples before Aging	Quenching Temperature deg. C	Aging Temperature deg. C.
ALLOY A				
1	Hardness vs. Aging Time	Quenched	900	450
			950	450
			1000	450
2	Hardness vs. Aging Time	Quenched	900	400
			900	450
			1000	400
			1000	450
ALLOY B				
4	Hardness vs. Aging Time	Quenched	900	450
			950	450
			1000	450
5	Hardness vs. Aging Time	Quenched	900	450
			900	500
			1000	450
			1000	500

Aging at temperatures in the neighborhood of 500 deg. C increases the steepness of the curve; however, the time factor is quite critical and alloys which have been cold worked after quenching, may overage.

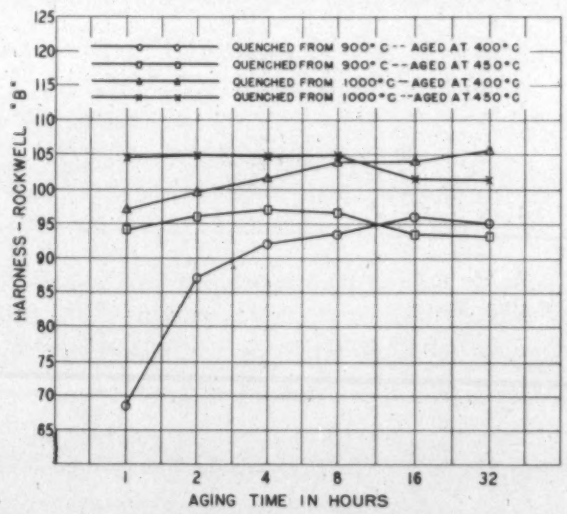
Table of Effect of Cold Working on Age Hardening

Curve No.	Ordinates	Condition of Samples before Aging	Quenching Temperature deg. C.	Aging Temperature deg. C.
ALLOY A				
3	Hardness vs. Aging Time	Quenched and Cold Worked	950	450
ALLOY B				
6	Hardness vs. Aging Time	Quenched and Cold Worked	950	450

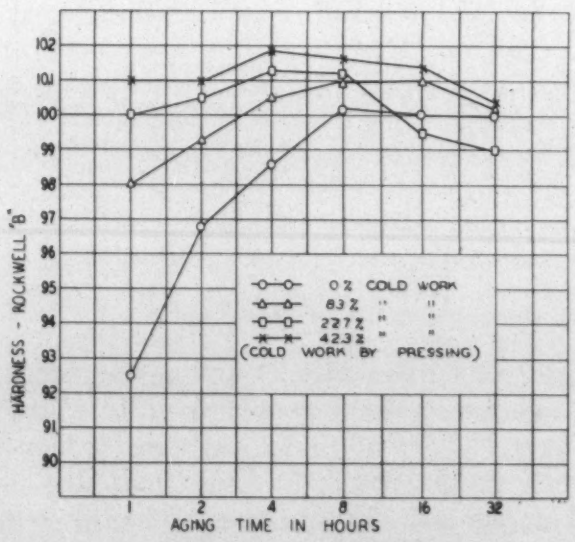
Referring to curves Nos. 3 and 4, numerous additional aging tests made on samples cold worked various degrees from 0 to 50 per cent reduction and quenched from 900, 950, and 1000 deg. C. disclosed in general that the rate of hardness increase during aging is in direct relationship to the amount of cold reduction prior to aging. The maximum hardness obtainable for each of the alloys was 105 Rockwell B for Alloy A and 97 Rockwell B for Alloy B after quenching, cold working and aging.



Curve No. 1—Alloy A. Age hardening as a function of quenching temperature. All samples aged from "as quenched" condition. Aging temp. 450 deg. C.


QUENCHED FROM 900° C -- AGED AT 400° C
QUENCHED FROM 900° C -- AGED AT 450° C
QUENCHED FROM 1000° C -- AGED AT 400° C
QUENCHED FROM 1000° C -- AGED AT 450° C
HARDNESS - ROCKWELL "B"
AGING TIME IN HOURS

Curve No. 2—Alloy A. Age hardening as a function of aging temperature. All samples aged from "as quenched" condition.



Curve No. 3—Alloy A. Age hardening as a function of the degree of prior cold working. Original samples quenched from 950 deg. C. All samples cold worked in quenched state. Aging temp. 450 deg. C.

Effect of Cold Work on Hardness and Electrical Conductivity

The alloys were found to have quite a high rate of cold working. The hardness reaches nearly the maximum at a reduction of 20 per cent after which the hardness increases but slightly. Curve No. 7 shows graphically the relationship between the amount of cold working and the hardness and electrical conductivity of both Alloy A and Alloy B.

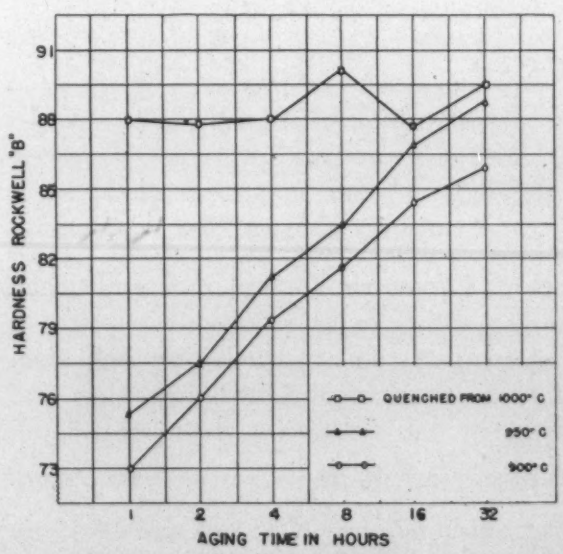
Effect of Aging on the Electrical Conductivity

The electrical conductivity was determined on the alloys after quenching from 950 deg. C., cold working and aging at 450 deg. C. The data for Alloys A and B are contained in curve No. 8. Up to an aging time of 32 hrs., the curves have not flattened out, the conductivity of Alloy A having reached a value of 57 per cent I.A.C.S. and the electrical conductivity of Alloy B having reached a value of 47 per cent I.A.C.S.

Annealing Characteristics

In the manufacture of Alloys A and B, it is necessary to anneal the metal at different stages of processing so that they may be drawn, rolled or swaged further.

The results of annealing tests for Alloy A are given in curve No. 9, and for Alloy B in curve No. 10. It is of interest to note that the shape of the curves is similar for both alloys. If the annealing temperature of Alloy A exceeds 900 deg. C., the material will harden during air cooling. In Alloy B this hardening takes place at an annealing temperature of 900 deg. C. with a subsequent air cooling. This harden-



Curve No. 4—Alloy B. Age hardening as a function of quenching temperature. All samples aged from "as quenched" condition. Aging temp. 450 deg. C.

ing phenomenon is very interesting and from the curves it will be noted that when Alloy B was quenched from temperatures above 900 deg. C. the hardness materially increased; for example, when Alloy A was quenched from temperatures of 900, 950, and 1000 deg. C. the hardness values of the quenched materials were 33, 43, and 75 Rockwell B, respectively.

This observation is very important from a production viewpoint since the intended effect of softening the materials by annealing may not be obtained at all if the incorrect temperatures are chosen. The increase of hardness as noted above may have resulted from precipitation during cooling.

"Birch-Bark" Effects in Alloys A and B

During processing, the alloys were subjected to high temperature treatments in an air atmosphere. This caused the formation of two definite oxide layers. The outer oxide layer is quite brittle and can be readily removed, and consists primarily of Cu_2O.

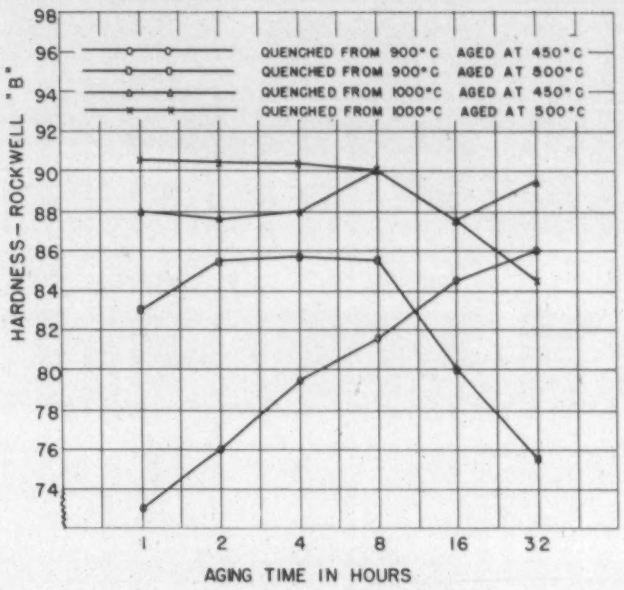
The analysis of the outer oxide layer of Alloy A was as follows:

Copper	84.25
Cobalt	2.99
Beryllium	0.34
Silicon	0.25
Oxygen (by diff.)	12.17

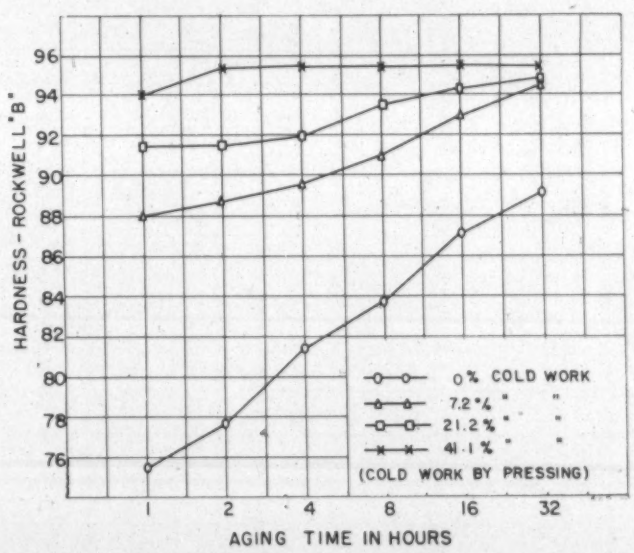
The chemical analysis of the outer oxide layer of Alloy B was as follows:

Copper	84.33
Cobalt	2.47
Cadmium	0.39
Phosphorus	0.40
Silicon	0.24
Oxygen (by diff.)	12.17

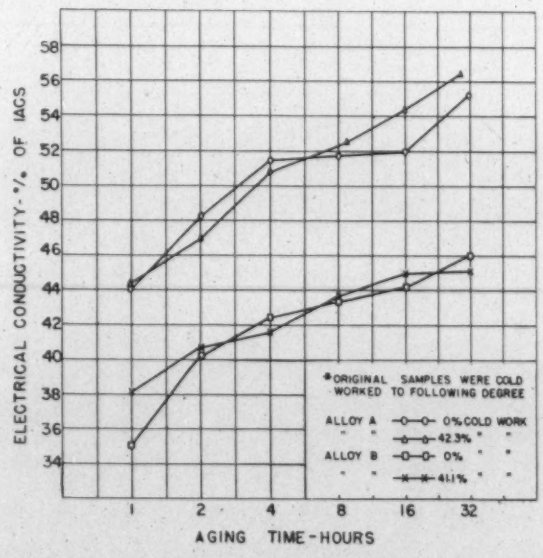
The sub-scale layer of Alloy A was quite tenacious but it could be detached by stressing and bend-



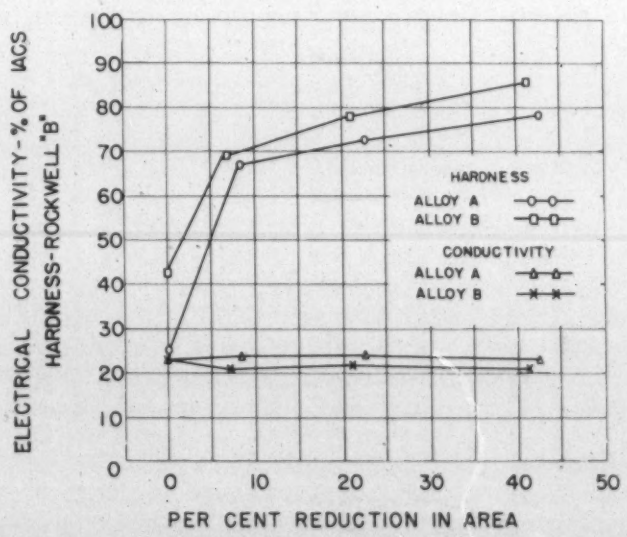
Curve No. 5—Alloy B. Age hardening as a function of aging temperature. All samples aged from "as quenched" condition.



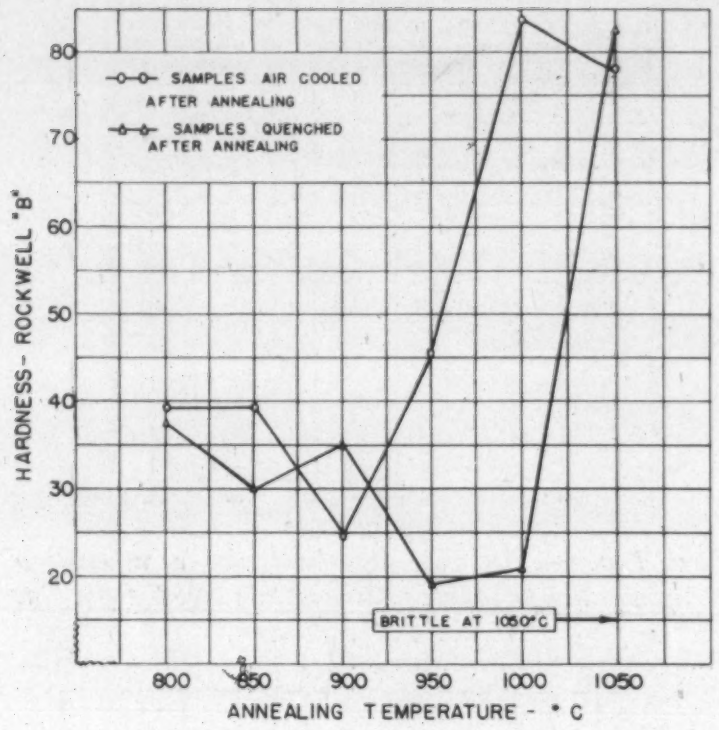
Curve No. 6—Alloy B. Age hardening as a function of the degree of prior cold working. Original samples quenched from 950 deg. C. All samples cold worked in quenched state. Aging temperature 450 deg. C.



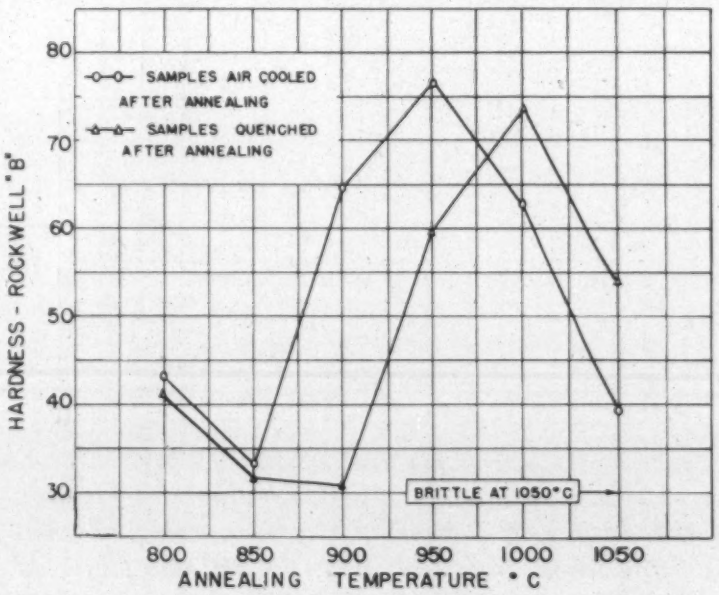
Curve No. 8—Alloys A and B. Electrical conductivity as a function of aging. Original samples quenched from 950 deg. C. Cold worked by pressing to degrees indicated. Aging temperature 450 deg. C.



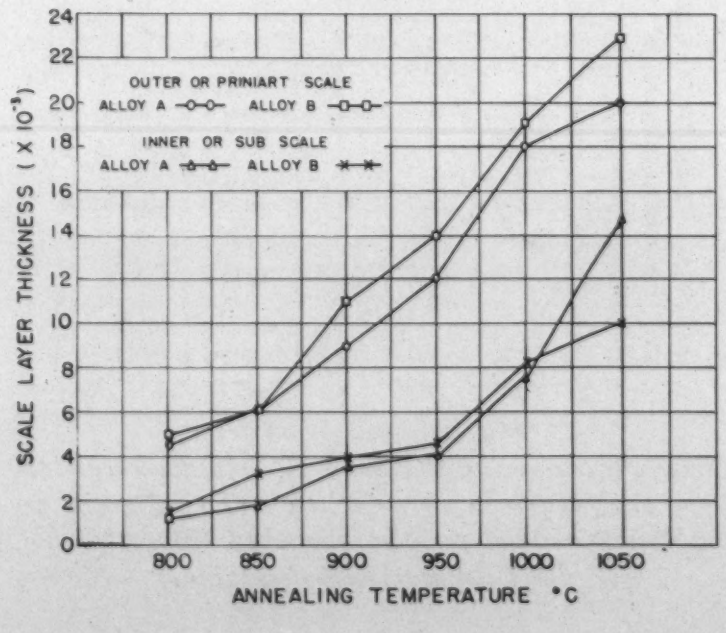
Curve No. 7—Alloys A and B. Electrical conductivity and hardness as a function of cold work on samples. Original samples quenched from 950 deg. C. Cold worked by swaging.



Curve No. 9—Alloy A. Hardness as a function of annealing temperature. Annealing time 2 hrs. at temperature. Sample hardness before annealing, 100 Rockwell "B."



Curve No. 10—Alloy B. Hardness as a function of annealing temperature. Annealing time 2 hrs. at temperature. Sample hardness before annealing, 96 Rockwell "B."



Curve No. 11—Scale formation as a function of annealing temperature. Individual samples annealed for 2-hr. period at each annealing temperature in the presence of air.

ing the test pieces. The chemical analysis of the inner or subscale of Alloy A was as follows:

Copper	94.45
Cobalt	2.76
Beryllium	0.43
Silicon	0.35
Oxygen (by diff.)	2.01

The sub-scale layer formed in Alloy B during annealing was very tenacious and could not be detached from the rolled samples. The thickness of the two oxide layers was measured as a function of the annealing temperature on samples held 2 hrs. at temperature. The increase of the oxide layer thickness of both Alloys A and B as a function of the annealing temperature is shown in Curve No. 11.

The formation of the sub-scale is extremely harmful if these materials are used in strip form for springs and reeds because the intercrystalline penetration of the oxide reduces the fatigue limit very materially. A considerable number of tests were conducted to overcome this birch-bark effect. Ordinary city gas did not eliminate the formation of the oxide layers. It was necessary to use hydrogen to eliminate oxide penetration. Experiments were also conducted, using various kinds of reducing salt baths for annealing. It was found that this also constituted a satisfactory means of overcoming the harmful birch-bark effect.

Conclusions

The results presented in this short paper were obtained on two proprietary alloys****. The information, however, is applicable to other heat treatable copper base alloys containing highly oxidizable ingredients.**** U. S. patents covering these alloys are:

Alloy B	*Alloy A*
U. S. Patent 2,145,792	U. S. Patent 2,135,336
2,130,737	2,139,497
2,142,672	2,135,254
2,177,745	2,142,671
2,140,910	
2,130,738	
2,123,629	

Producing Cast Iron Pipe Centrifugally

PHOTOGRAPHS BY DON GRAF

Staff Photographer, Reinhold Publishing Corp.

Text and Captions by Edwin F. Cone

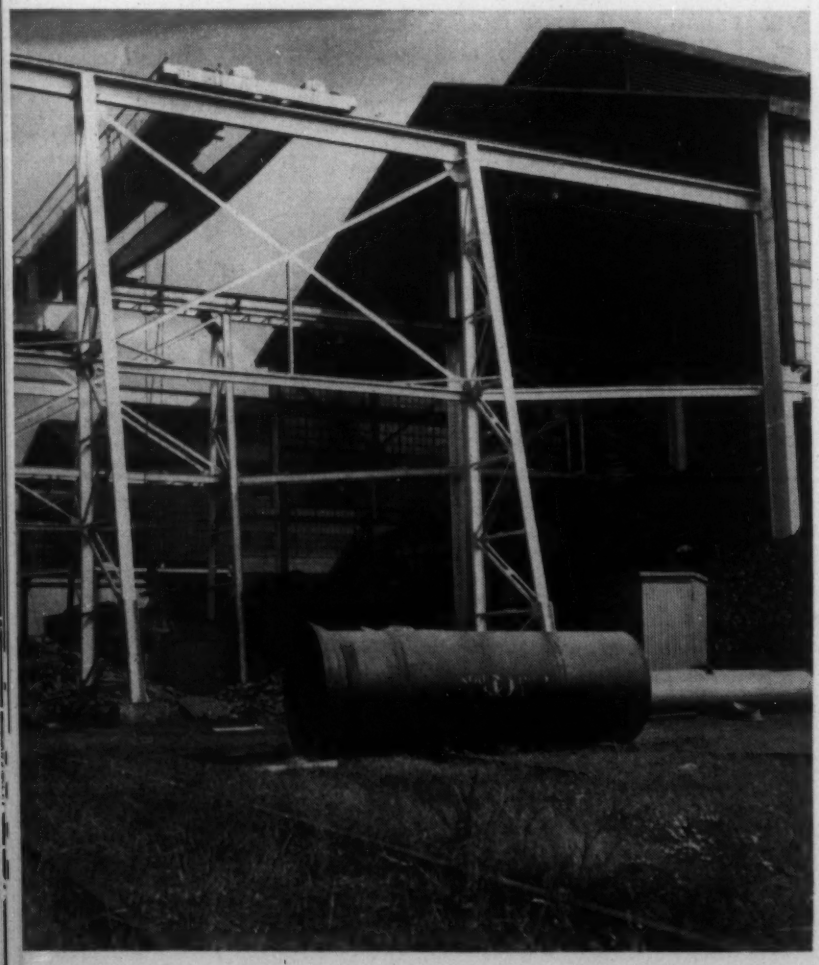
TWENTY-FIVE YEARS AGO there appeared in the United States an inventor from Brazil who claimed he had a process for producing cast iron pipe by a centrifugal process. His name was DeLavaud.

Following the editorial news instinct, the writer was commissioned to investigate this claim. He stopped at Buffalo, N. Y., on his return from a convention in the West and found an enthusiastic Brazilian with a crude machine, about 3 to 4 ft. long, in which he had a revolving cylindrical mold. In the corner of a small iron foundry, he was able to demonstrate on a very small scale the production of pipe from hot metal. Your editor came away, convinced that Mr. DeLavaud "had something." The first article on this subject was published in "The Iron Age," Sept. 7, 1916, under the title "Centrifugal Machine for Casting Pipe."

From that simple beginning a large industry has developed—after many setbacks and headaches. Today a large share of the cast iron pipe made in the United States is produced by this and one other centrifugal process.

Now, 25 years after that incident, it is possible to publish a pictorial article showing the various steps in this most interesting industrial process. They were taken at the plant of the United States Pipe and Foundry Co., at Burlington, N. J.,—a company which, through much research and experimentation, has "ironed out the bugs" and brought the process to its present perfected state.

Contrasted with the old pit process of making pipe, the centrifugal has many advantages, though some customers still prefer the former. In these centrifugal machines, when running to capacity, pipe can be turned out on the average of 10 to 30 lengths per hr., depending on the size.



(Above) Down a chute the pig iron and other necessary materials are dumped into one of the several cupolas in which they are converted by melting into molten cast iron, ready for casting.

(Left) The Raw Materials Stock Yard: From the piles of foundry pig iron, scrap iron and coke, magnets and cranes place the materials in charging boxes which are carried to the cupola charging platforms by the traveling crane.

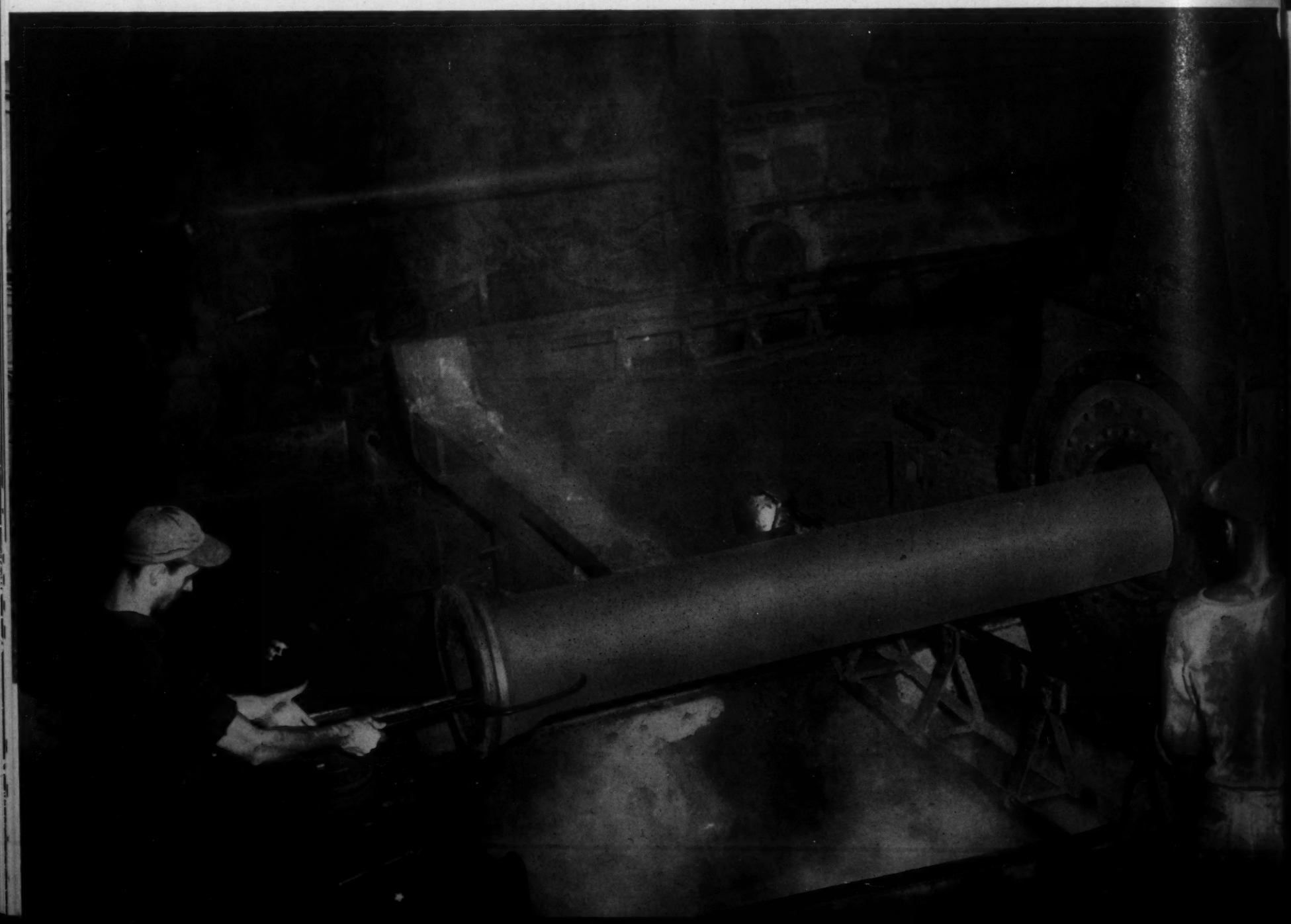
The lower end of one of the cupolas from which the hot liquid cast iron flows into a forehearth. From this it runs into small ladles ready for transfer to the centrifugal casting machines.

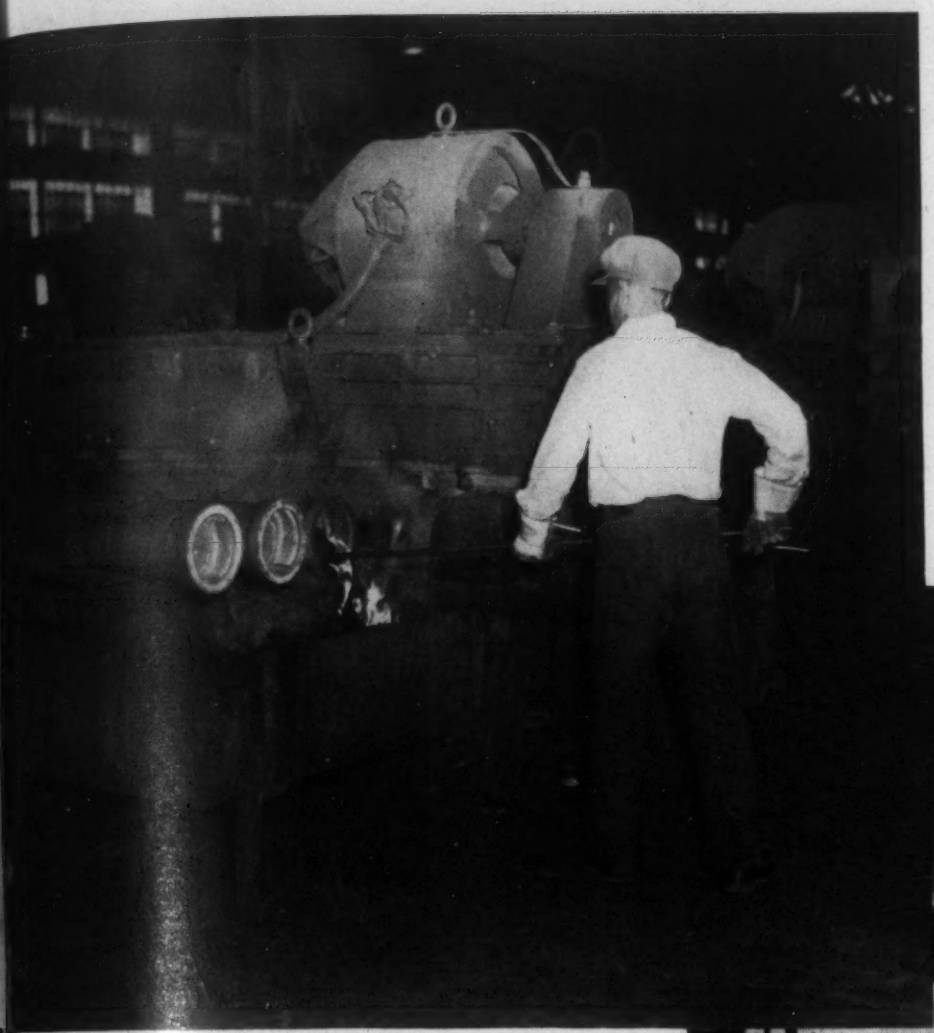
Suspended from a traveling crane, the molten cast iron in the ladle is poured into the machine ladle located at one end of the centrifugal casting machine.

FEBRUARY, 1941

A trough runs from the hopper to and through the inside of the centrifugal machine. As this machine, with its revolving alloy steel mold inside, travels from one end of the trough to the other, the molten cast iron is deposited on the mold's surface forming a pipe of the desired thickness and length. A 12-in. pipe is being cast in this picture. A battery of four machines enables the casting of pipe from 3-in. to 24-in. diameter, in 12 ft. and 14 ft. lengths.

Extracting a red-hot cast iron pipe from the end of one of the centrifugal machines. The thickness is also being calibrated. This is a 12-in. pipe. In the background is a machine from which a smaller pipe is being extracted just after casting.





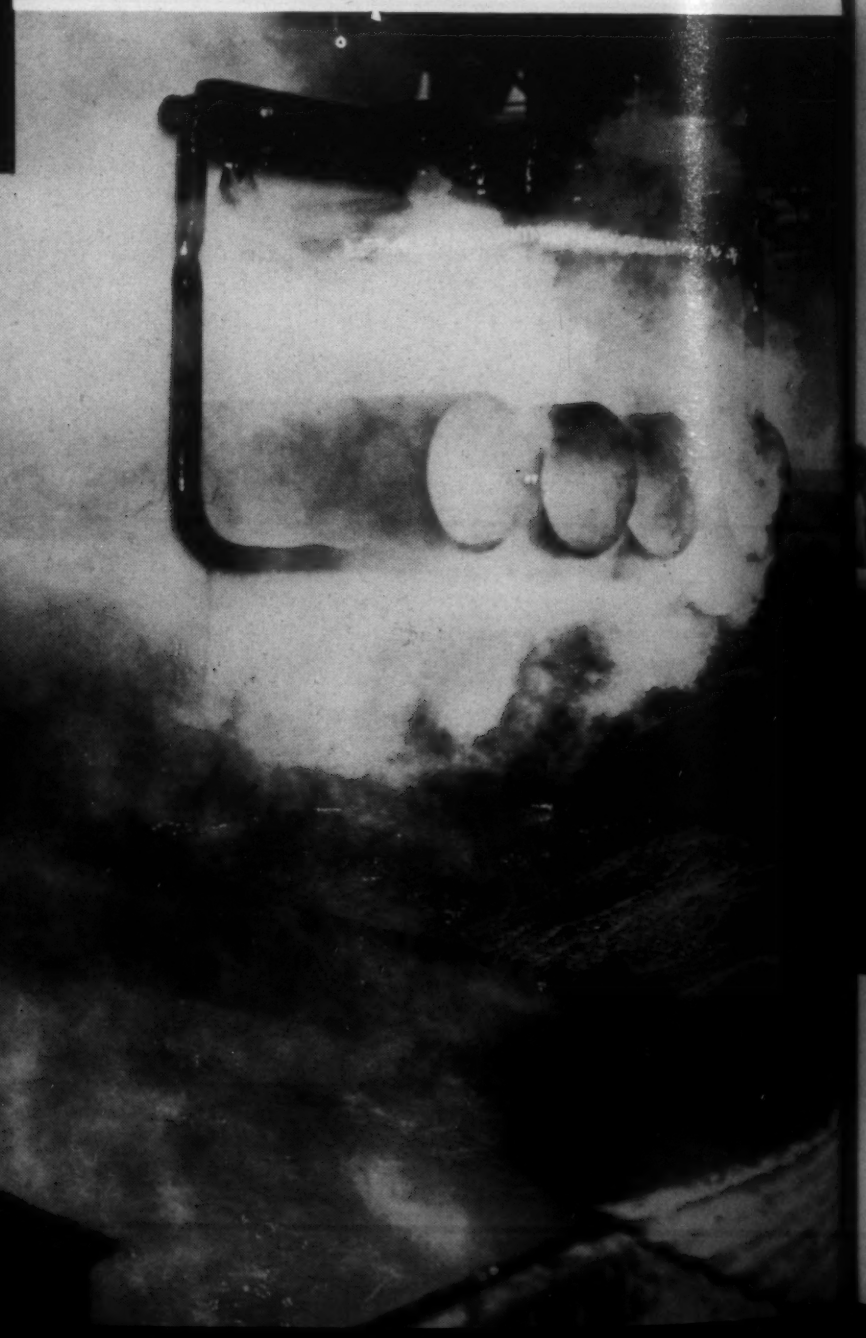
In one end of the mold in each machine, a dry sand core is inserted after each casting operation, which forms the inside contour of the bell end of the pipe. It is being removed in this view.

Very soon after withdrawal from the centrifugal machine and while still quite hot, each pipe is transferred to a heat-treating furnace where it is annealed. The charging end of the furnace is here shown.

side-view of the heat-treating furnace which quite large—about 80 ft. long. It contains ee zones: A pre-heating, a heating and a cooling. It is fired with oil.

The pipe come out of the annealer at a black heat. Before they are immersed in pitch, their temperature is taken with a pyrometer.

A batch of pipe as they come out of the liquid bath of pitch or tar directly below. A dense white smoke is one result.



All pipe are tested in a hydraulic testing machine where they are subjected to 500 lbs. of pressure.

After leaving the hydraulic machine, the pipe are sorted for size and shipment, and placed in the pipe yard.

Practical Metallography of the S

Effect of Chromium and Nickel

The effect of chromium on the structure and constitution of iron may be summarized as follows:

1. It lowers the carbon content of pearlite to the extent that an alloy with about 12 per cent Cr is rendered wholly pearlitic with only 0.30 per cent C.
2. Structural changes are slowed down by the addition of chromium, necessitating a higher temperature and longer heating period to dissolve carbides than required for ordinary steel.
3. In pure iron-chromium alloys, as shown by Fig. 11, the effect of chromium is to lower both the A_3 and A_4 critical points until they finally merge at about 13 per cent Cr. Thus, carbon-free alloys with chromium in excess of this amount undergo no transformation and consequently are not amenable to hardening by heat treatment. However, when carbon and nickel are added in appreciable amounts, their effect is to deflect the curve to the right and thereby extend the range of composition which may be hardened by heating above the critical point and cooling rapidly.
4. It causes the steel to harden at a much slower rate of cooling and, with about 12 per cent Cr present, the rate is so retarded that the steel hardens when air cooled.

The addition of nickel to the iron-chromium stainless steels containing approximately 18 per cent Cr causes their structural transformations to become so sluggish that a relatively small amount of nickel will allow the retention of austenite in an unstable condition at ordinary temperatures. As will be seen by Fig. 12, less than 2 per cent Ni serves to alter the ferritic structure of an 18 per cent Cr stainless steel with negligible carbon content. However, as nickel content is increased, the proportion of austenite formed at elevated temperatures increases until at about 4 per cent Ni the alloy is wholly austenitic in the range of 1250 to 1850 deg. F. Further increase in nickel content lowers the temperature at which a fully austenitic alloy is obtained. The austenite formed in these iron-chromium-nickel stainless steels at elevated temperatures is readily preserved by rapid cooling owing to their atomic sluggishness toward any change involving structural transformation. From a practical standpoint, this instability of the austenitic stainless steels has no bearing on their normal use, but does render it possible to improve their tensile properties by cold work. This is an important con-

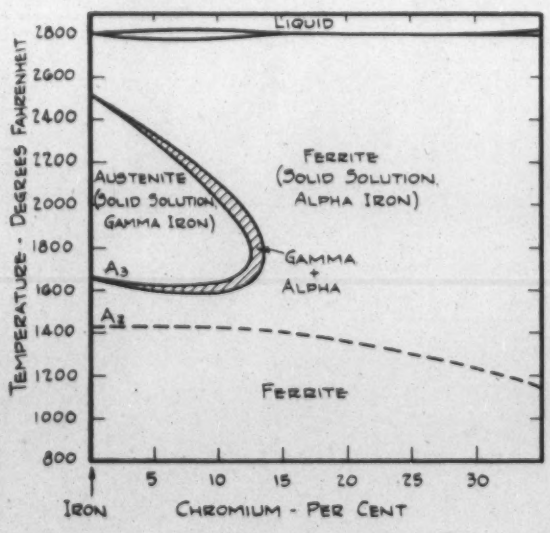


Fig. 11. Iron-chromium diagram. When chromium is above 13 per cent in low carbon alloys, they cannot be hardened to any extent by heat treatment. (Wever and Jellinghaus)

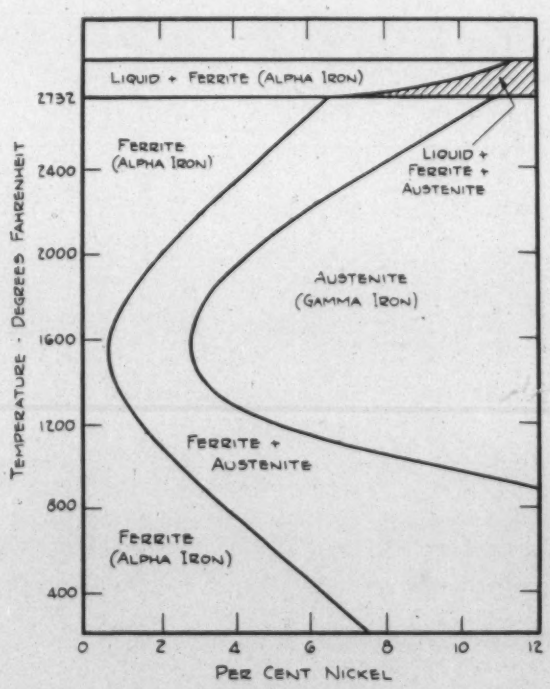


Fig. 12. Structural diagram for carbon-free 18 per cent Cr alloys with variable nickel. (Aborn, Bain, Krivobok and others)

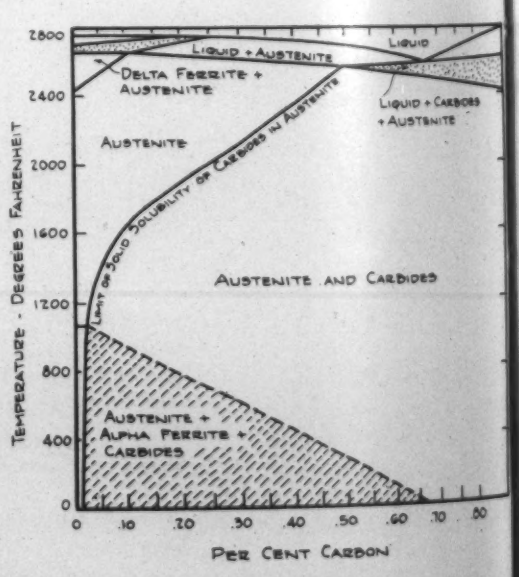


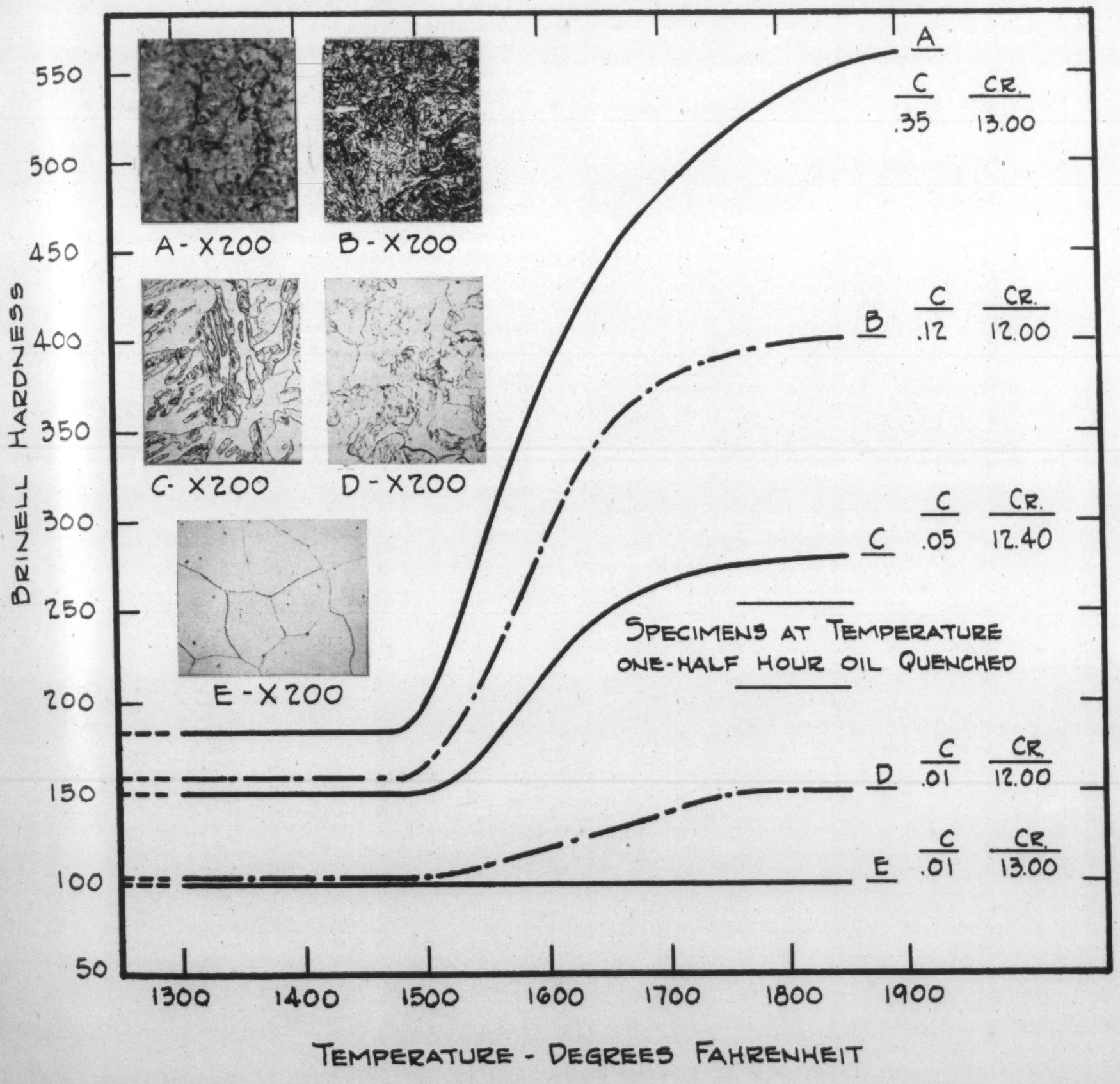
Fig. 13. Structural diagram for 18 per cent Cr-8 per cent Ni alloys with varying carbon content. (Aborn, Bain and others)

he Stainless Steels–II

by STANLEY P. WATKINS

Manager, Development Division,
Rustless Iron and Steel Corp.
Baltimore, Md.

Fig. 14. Effect of carbon on the structure and hardenability of the 12 per cent Cr stainless steels.



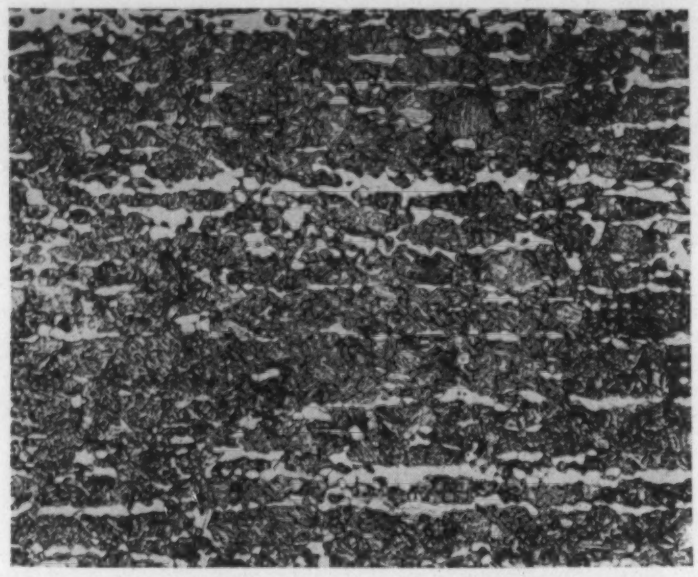


Fig. 15. Hardened structure of an 0.08 per cent C, 12 per cent Cr stainless steel consisting of chromium-ferrite pools in martensitic matrix. Hardness 363 Brinell. Etchant: 10% HCl in alcohol, electrolytic. Mag. 100X.

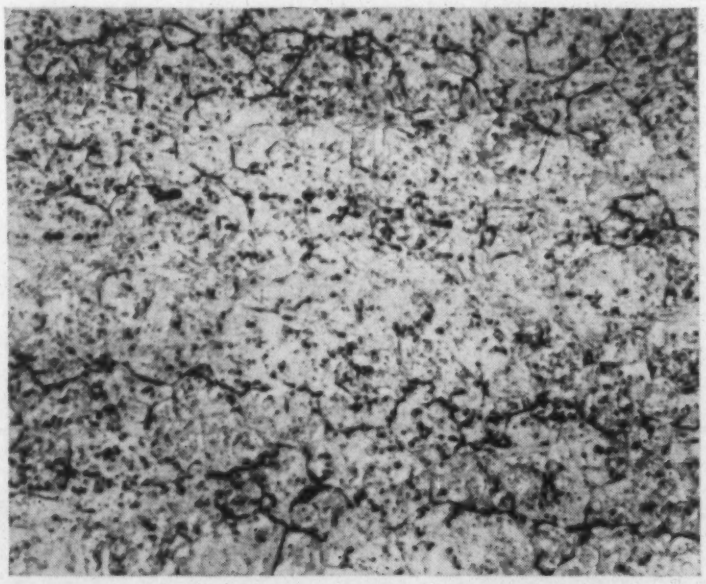


Fig. 16. Hardened structure of a 0.35 per cent C, 13 per cent Cr stainless steel consisting of martensitic matrix with imbedded carbide particles. Etchant: HCl-picric reagent. Hardness 555 Brinell. Mag. 500X.

sideration since it is the only means whereby this can be accomplished.

Effect of Carbon

When appreciable amounts of carbon are added to the straight chromium stainless steels, the carbon serves to extend the range where austenite, or gamma iron, will be formed at elevated temperatures. A similar effect is exercised by this element at high temperatures upon the high chromium-nickel stainless steels, such as the 18 per cent Cr and 8 per cent Ni grade. Although nickel is an effective austenite former at elevated temperatures when added to the straight chromium stainless steels, carbon is about 40 times more effective than nickel in this respect and the combined effect of the two acting simultaneously is greater than would be normally expected from an estimation of their actions when used singly. In contrast to nickel, which remains in solid solution in the chromium-nickel stainless steels at all temperatures, carbon becomes highly insoluble at temperatures below about 1650 deg. F., and if the alloy is held in the range of 900 to 1650 deg. F. for any appreciable time, practically all the carbon will precipitate out as chromium carbides along the grain boundaries and slip planes. However, the carbon may be retained entirely in solid solution by cooling rapidly from about 1650 deg. F.

The Four Stable Phases

In the various stainless steels only four stable phases have been observed: Austenite, sigma, carbides and ferrite. In addition, martensite is a constituent of the hardened straight-chromium stainless

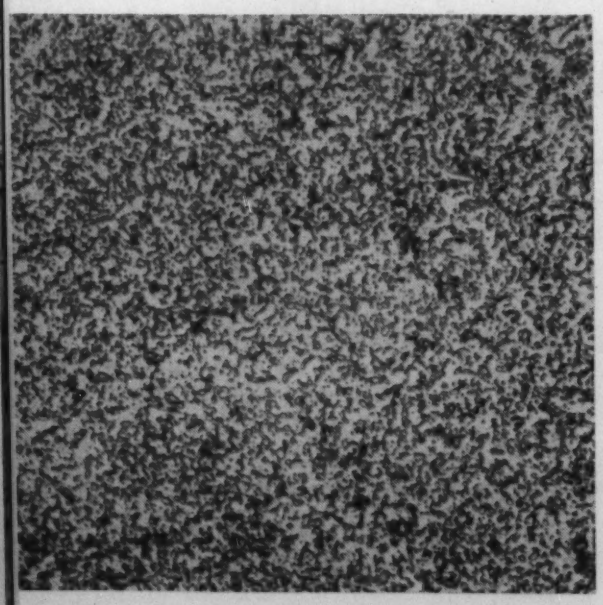


Fig. 17. Annealed structure of a 0.35 per cent C, 13 per cent Cr stainless steel. Chromium carbides imbedded in ferrite matrix. Hardness 180 Brinell. Etchant: HCl-picric reagent. Mag. 500X.

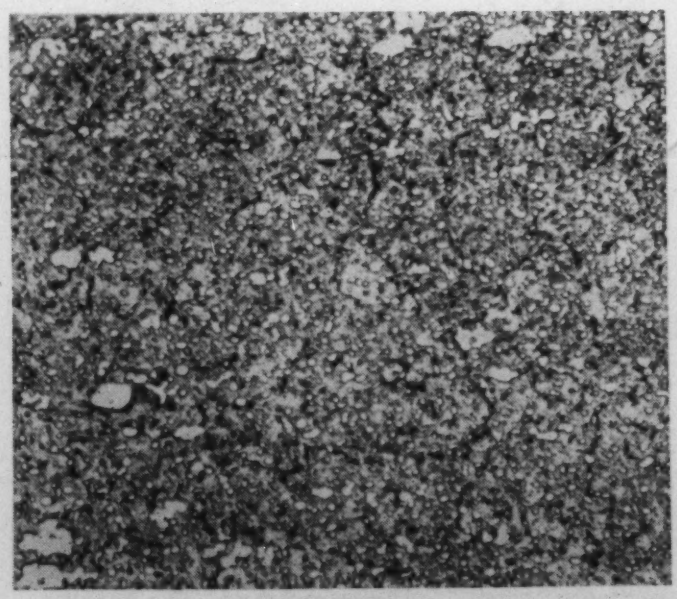


Fig. 18. Hardened structure of a 1.00 per cent C, 17 per cent Cr stainless steel. Large carbide particles imbedded in martensitic matrix. Hardness 627 Brinell. Etchant: HCl-picric reagent. Mag. 500X.

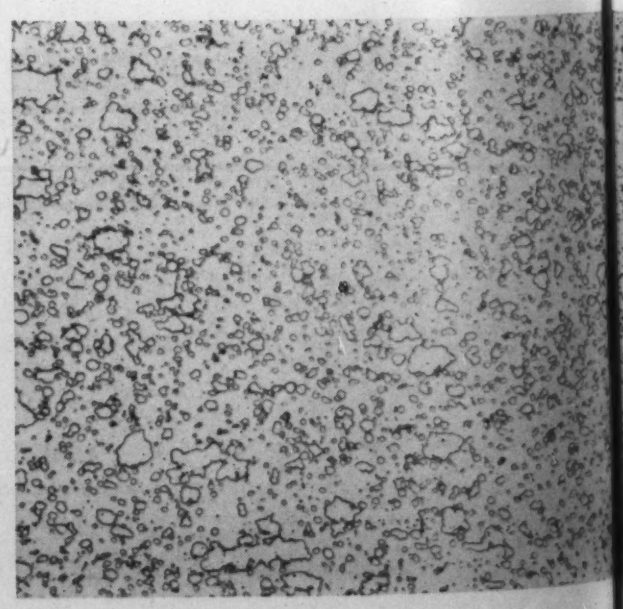


Fig. 19. Annealed structure of a 1.00 per cent C, 17 per cent Cr stainless steel. Large carbide particles imbedded in ferritic matrix. Hardness 201 Brinell. Mag. 500X.

steels and results from the transformation of austenite to ferrite at fairly low temperatures. With favorable heat treatment a portion of the martensite may transform to troostite, which is the next step in the transformation of martensite to ferrite and carbides.

Austenite is the solid solution, gamma form of iron, non-magnetic, highly ductile and readily identified under the microscope by characteristic twinning of grains. Its crystallinity is like that of pure metals and is termed "face centered cubic" by crystallographers. Austenite formed in the stainless steels is often referred to as "chromium-austenite."

"'B' constituent" or sigma phase occurs in certain analyses of both the straight chromium and chromium-nickel stainless steels. It is hard, brittle, non-magnetic and corresponds approximately to the compound FeCr. Sigma phase occurs in the straight chromium stainless steels having chromium between 20 and 30 per cent and in the chromium-nickel grades, which are not purely austenitic when cooled rapidly from high temperatures but contain some free ferrite (alpha or delta iron). On prolonged heating in the temperature range of 1100 to 1650 deg. F., a portion of the ferrite is converted into the compound FeCr and austenite. This change is accompanied by a pronounced decrease in volume and decrease in ductility.

With suitable heat treatment, such as annealing, carbon present in the stainless steels will combine with chromium to form a compound Cr_4C, which generally precipitates out as spheroidized particles. This carbide is more stable than the iron carbide Fe_3C which it resembles in microscopic appearance. All the commercial grades of stainless steel carry appreciable amounts of carbon as it is not practicable nor desirable in many cases to produce carbon free alloys.

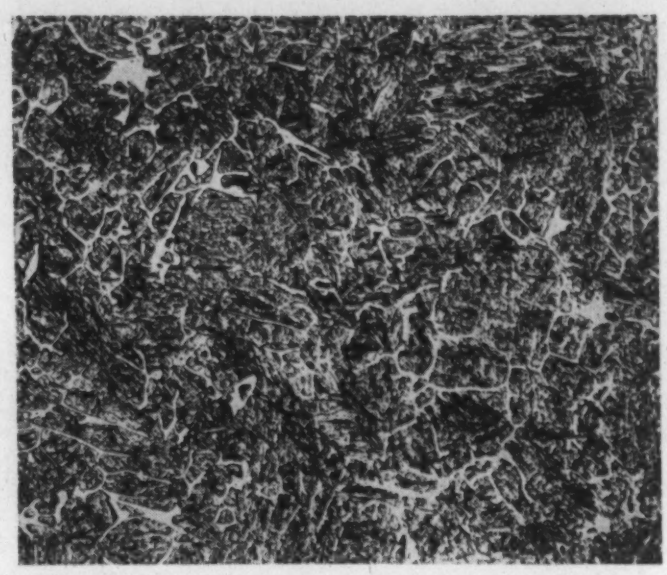


Fig. 23. Cast structure of 0.12 per cent C, 12 per cent Cr stainless; 2 in. square section. Ferrite (white areas) in martensitic matrix. Hardness 375 Brinell. Etchant: 10% HCl in alcohol, electrolytic. Mag. 100X.

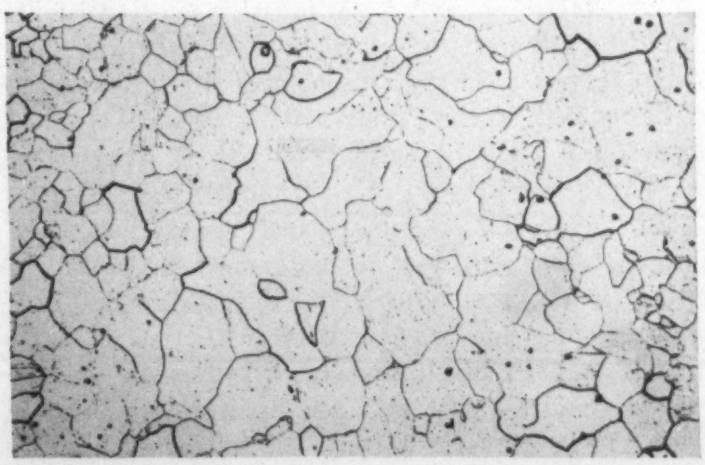


Fig. 24. Annealed structure of 0.01 per cent C, 12 per cent Cr stainless steel. Entirely ferritic. Hardness Rockwell "B" 57. Etchant: 10% HCl in alcohol, electrolytic. Mag. 100X.

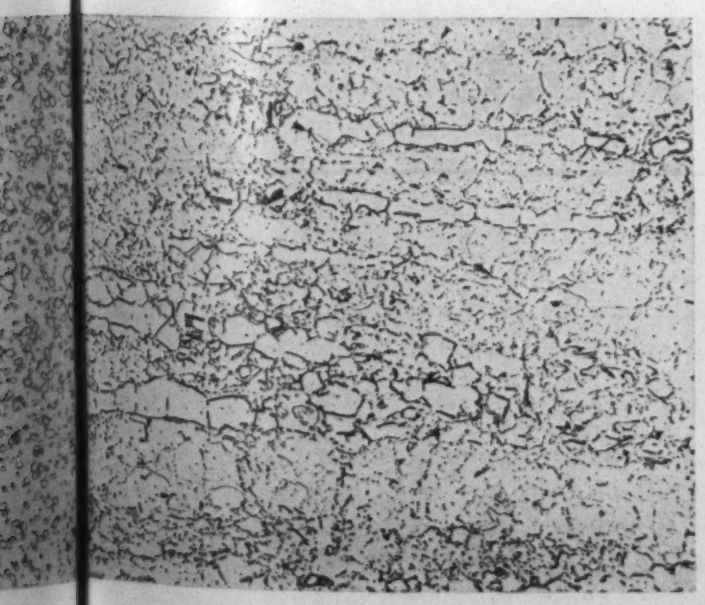


Fig. 20. Annealed structure of a 0.12 per cent C, 12 per cent Cr stainless steel. Carbides in ferrite matrix. Hardness 160 Brinell. Etchant: 10% HCl in alcohol, electrolytic. Mag. 200X.

Fig. 21. Hardened structure of 0.12 per cent C, 12 per cent Cr stainless steel. Uniformly martensitic. Hardness 401 Brinell. Etchant: 10% HCl in alcohol, electrolytic.

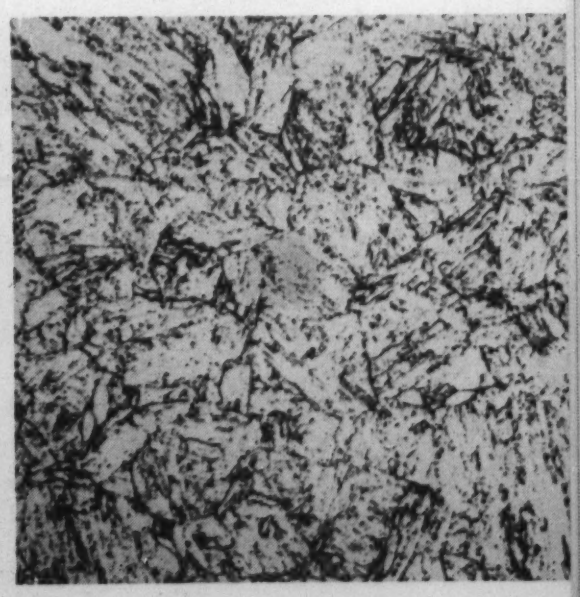


Fig. 22. Tempered structure of hardened 0.12 per cent C, 12 per cent Cr stainless steel. Martensite has partly decomposed into ferrite and carbides and possibly some troostite. Hardness 228 Brinell. Etchant: HCl-picric reagent. Mag. 500X.

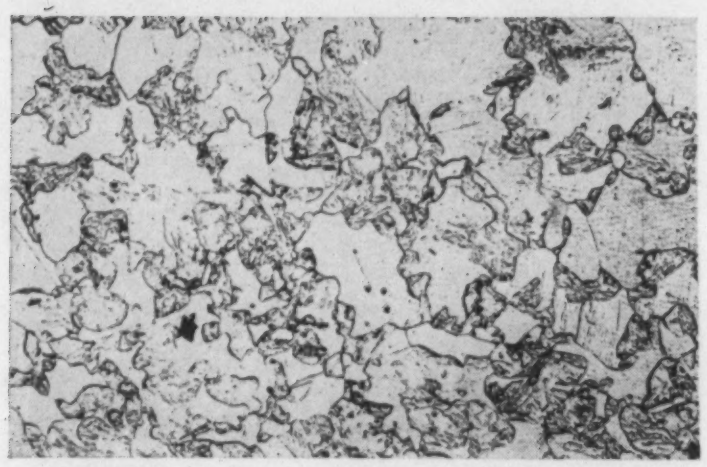


Fig. 25. Structure of 0.01 per cent C, 12 per cent Cr after quenching from 1750 deg. F. consisting of martensite in ferritic matrix. Austenite is formed on heating due to chromium not being high enough to render alloy entirely ferritic. Hardness Rockwell "B" 84. Etchant: 10% HCl in alcohol. Mag. 200X.

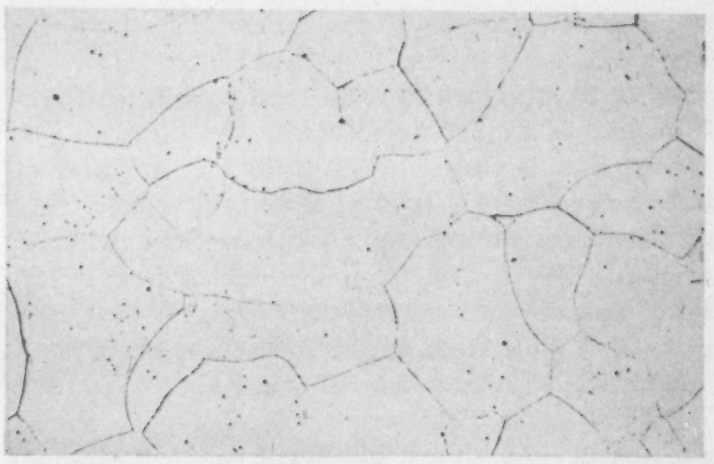


Fig. 26. Structure of 0.01 per cent C, 13 per cent Cr stainless steel after quenching from 1800 deg. F. Chromium is sufficient to place the alloy outside the "gamma loop"; consequently no austenite is formed on heating and no hardening occurs on quenching. Hardness Rockwell "B" 55. Etchant: 10% HCl in alcohol, electrolytic. Mag. 200X.

Ferrite is the solid solution, alpha or delta form of iron, highly magnetic, and usually associated with carbides in annealed straight-chromium stainless steels. It possesses the arrangement of atoms which is designated as the "body-centered cubic" type of crystallinity. "Chromium-ferrite" is the term generally given to ferrite occurring in the stainless steels.

When chromium-austenite transforms to chromium-ferrite at relatively low temperatures, the dissolved carbon is not visibly precipitated and the resulting alloy is quite hard and very magnetic. Under the microscope the etched structure of martensite formed in the stainless steels is "acicular" in appearance. Owing to its low carbon content the hardness of this martensite is not as great as that formed in ordinary steel.

Although there are over 60 different grades of stainless steel commercially available, over 90 per cent of the production is in 15 grades. Of these 15 grades, 18 and 8 and its variations account for the bulk of the tonnage, especially in flat rolled products such as sheet, strip and plate. However, in the case of bar and wire products, 18 and 8 does not bulk as great, since large tonnages of the straight chromium stainless steels, such as the 12 and 17 per cent Cr grades are produced in these forms.

Types of Stainless Steels

Variation of the combination and proportion of chromium and nickel with supplementary additions of other alloys results in the production of several types of stainless steels which can be classified from a metallographic standpoint in three distinct groups.

Group I—Straight chromium stainless steels—Martensitic (Hardenable)
Analysis range: C 0.05 to 1.10 per cent and Cr 11.0 to 18.0 per cent, plus small supplementary additions of molybdenum, sulphur and nickel.

Group II—Straight chromium stainless steels—Ferritic (Non-hardenable)
Analysis range: C 0.05 to 0.35 per cent and Cr 14.0 to 30.0 per cent, plus small supplementary additions of molybdenum and sulphur.

Group III—Chromium-nickel stainless steels—Austenitic (Hardenable by cold work only)
Analysis range: C 0.05 to 0.20 per cent, Cr 17.0 to 29.0 per cent and Ni 7.0 to 14.0 per cent, plus supplementary additions of molybdenum, titanium, columbium, tungsten, sulphur, selenium.

The martensitic stainless steels contain the minimum amount of chromium which will produce adequate rust resistance to class them as truly stainless. Although the chromium content of the alloys in this group, in the absence of carbon, is sufficient to render them ferritic and consequently non-hardenable, the presence of carbon in amounts ranging from 0.05 to 1.10 per cent results in the formation of austenite on heating above the critical range, which upon fairly rapid cooling decomposes into martensite. Therefore, depending upon the carbon content, these stainless steels have a hardening range of 300 to 625 Brinell. The effect of carbon on the hardening properties of the martensitic stainless steels is shown graphically by Fig. 14. Also, this figure illustrates the structure of the various alloys after quenching from above the critical range and it will be noted that as the carbon increases, the proportion of martensite increases with consequent increase in hardness. With carbon below about 0.08 per cent, the alloy is not rendered entirely austenitic on heating above the critical range and, consequently, the hardened structure will consist of a mixture of martensite and chromium-ferrite as shown by Fig. 15. On the other hand, when carbon is increased to above the eutectoid point (0.30%), excess carbon is rejected

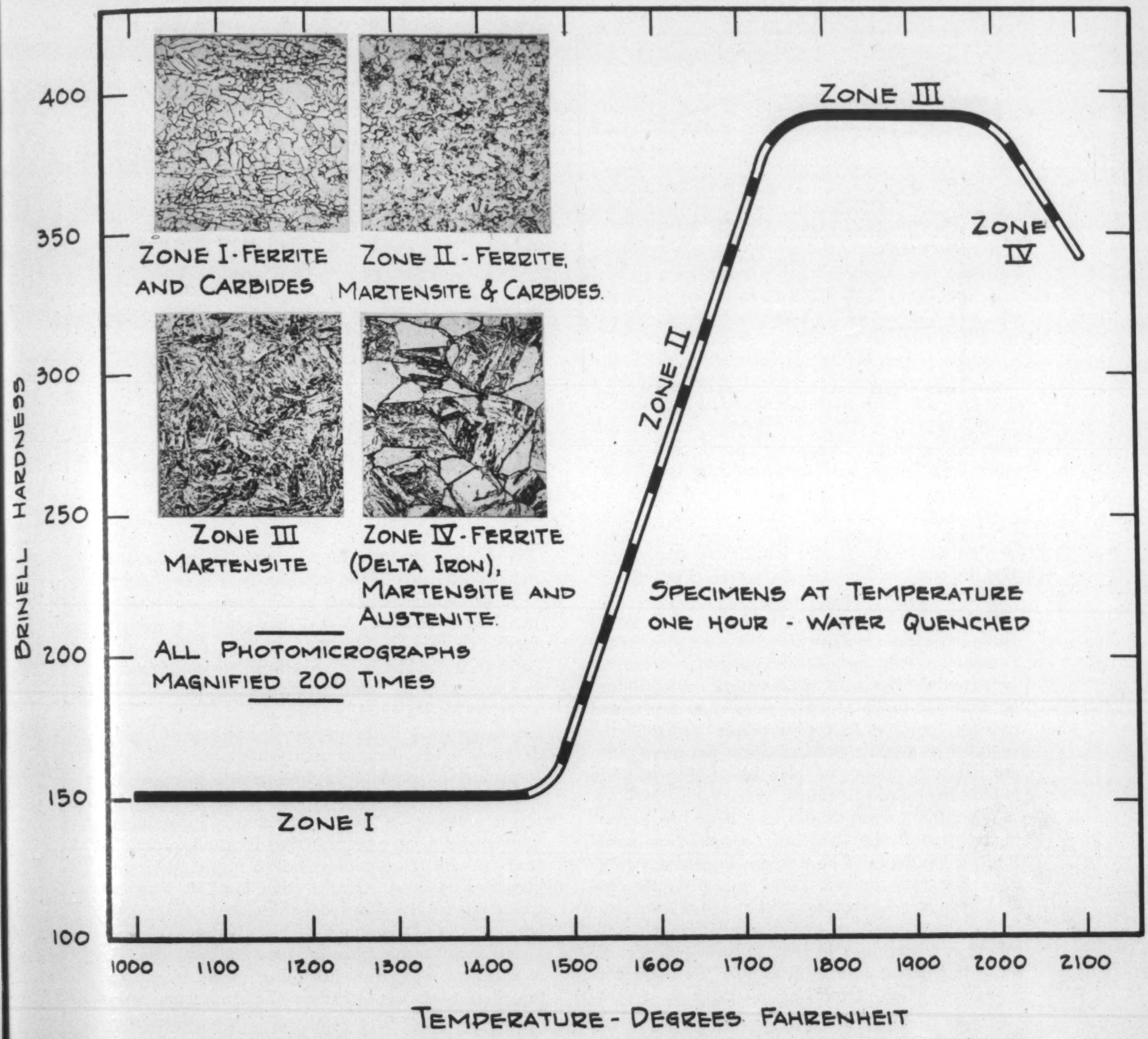


Fig. 27. Effect of heating on the structure and hardness of a 0.12 per cent C, 12 per cent Cr stainless steel.

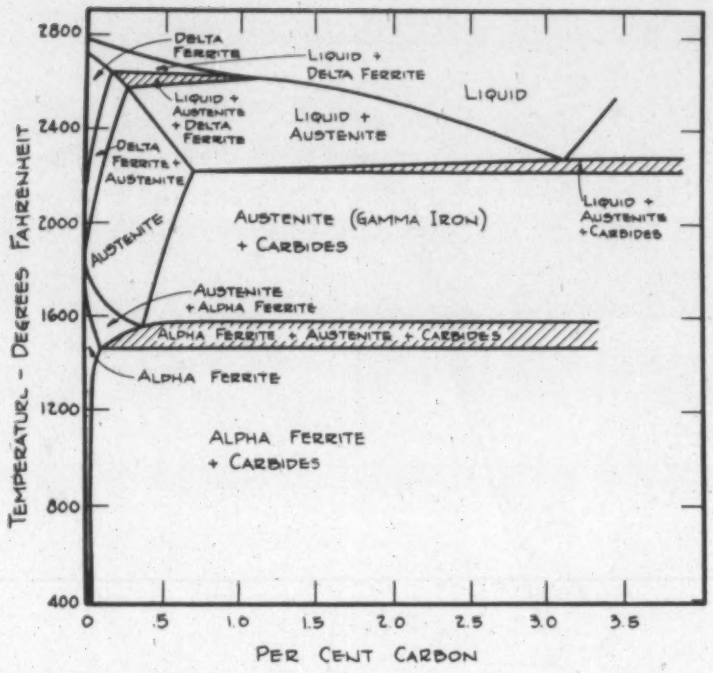


Fig. 28. Diagram of the 12 per cent Cr stainless steels with varying carbon content. (Book of Stainless Steels)

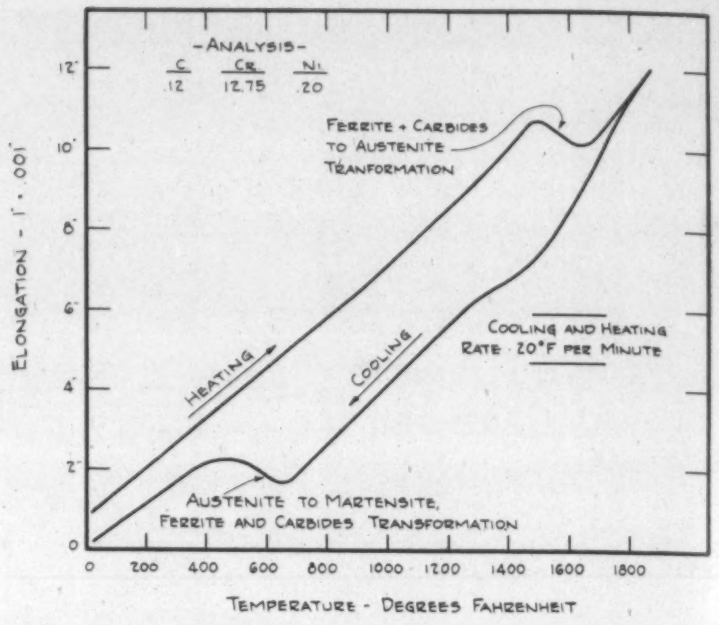


Fig. 29. Heating and cooling curve on 0.12 per cent C, 12 per cent Cr stainless steel showing change in volume occurring at structural change points.

and the hardened structure consists of carbide particles dispersed in a martensitic matrix (Fig. 16).

The structural changes occurring when the martensitic stainless steels are allowed to cool slowly from above their critical range is analogous to the changes occurring in plain carbon steels when similarly treated. The order of constituent decomposition is: Austenite to martensite to troostite to ferrite and carbides (pearlite). Lamellar pearlite occurs in the annealed martensitic stainless steels, but more often the structure consists of globular carbide particles imbedded in a ferritic matrix (Fig. 20).

When the martensitic alloys are heated to increasing temperatures and quenched, their structural transformation is indicated by a change in hardness (Fig. 27). The first austenite forms in a 0.12 per cent C, 12 per cent Cr stainless steel at about 1500 deg. F., but due to the slow rate at which carbide is dissolved, it is necessary to heat at least 200 deg. F. above this temperature in order to effect rapid and complete solution of carbides and to obtain a completely austenitic condition. On fairly rapid cooling from this range, such as oil quenching or air cooling, the austenite decomposes at a low temperature (Fig. 21) into martensite, which accounts for the hardening characteristics of the stainless steels in this group.

In hardening the alloys in this group with carbon in the neighborhood of 0.12 per cent, it is not advisable to heat above 1950 deg. F., as above this point considerable grain growth occurs accompanied by decrease in hardness on quenching. In addition, at high temperatures surface decarburization will occur, especially if the furnace atmosphere is highly oxidizing. The decrease in hardness is due to the formation of some delta iron which increases in amount as the temperature is raised and on quenching is preserved at room temperature. In addition, some austenite may be preserved by cooling rapidly from high temperatures which also decreases quenched hardness. On the other hand, it is necessary to quench the alloys containing above about 0.30 per cent C and chromium ranging between 12 and 17 per cent in the range of 1850 to 1950 deg. F. in order to effect full hardening. This is due to the effect of increased carbon and chromium, making the alloys more sluggish and hence increasing difficulty of completely dissolving carbides.

(To be continued)

Corrosion Fatigue of Notched Specimens

— Class 40 Cast Iron

by H. W. Russell and J. G. Lowther
Battelle Memorial Institute, Columbus, Ohio

IT IS WELL KNOWN that soft cast irons such as those of A.S.T.M. Class 20 are immune to notch effects in fatigue. A specimen with a square notch, a V notch, or one with a hole bored through it, shows endurance properties the same as those of a smoothly filleted bar of the same cross section. This is in sharp distinction to the notch sensitivity in fatigue of steels, which is high, even in a soft steel and increases so rapidly as the tensile strength of the steel is increased that, for use under repeated stress where stress concentration is not avoided, the increased fatigue resistance that is shown on a smoothly filleted bar is nearly or entirely nullified. That is, a strong steel may be worse in notched fatigue than a medium strength steel and the medium strength steel only a trifle better than a very weak one.

As cast iron is increased in strength, it shows some notch sensitivity till, in an A.S.T.M. Class 60 iron, the notch sensitivity would approach that of a soft steel and some of the value of high endurance on a filleted bar is cancelled. Somewhere in between the very soft and the very strong cast irons there should be a class in which the fatigue strength is relatively high and the notch sensitivity relatively low, i.e., a material of engineering importance for use under repeated stress where notches cannot be avoided. Corrosion, prior to repeated stress, produces pits and roughness whose effect is quite analogous to mechanically formed notches, as McAdam and Clyne,[1] Karpov,[2] and others, have shown.

In steels that are not thoroughly corrosion resistant, corrosion simultaneous with repeated stress nullifies, even more effectively than does a pre-formed notch, the value of strength so that, in corrosion fatigue of ordinary, non-corrosion-resistant steels, strength is of practically no import. The hard steels are as poor as the soft steels.[3]

In view of the remarkable notched fatigue resistance of cast iron, the question arises whether cast iron is also resistant to the notches of corrosion fatigue. Piwowarsky[4] studied prior corrosion (4 and 40 days in 3% NaCl, 0.1% H_2O_2) on a cast iron of 3.55 per cent C, 1.71 per cent Si, quenched from 1515 deg. and drawn 1 hr. at 840 deg. Stresses for a life of 10 million cycles were, not corroded, 19,500 lbs. per sq. in., corroded 4 days 14,000, and corroded 40 days 13,000.

Data on simultaneous corrosion-fatigue of cast iron are scarce, possibly because cast iron is not ordinarily thought of as a corrosion-resistant material. Ludwik[5] gives the following for a common and a special cast iron, whose compositions were not stated.

Tensile, Lbs. per sq. in.	Brinell	End. Limit, in lbs. per sq. in. Unnotched	End. Limit, in lbs. per sq. in. Notched	Stress, in lbs. per sq. in. for 10 million cycles in sea water. (Tests at 3000 r.p.m.) Unnotched.
16,500	162	10,000	10,000	6,500
35,000	272	19,500	19,500	10,500

Dolan[6] has shown that the combined effect of simultaneous corrosion and repeated stress on a notched specimen of SAE 3140 steel is exceedingly great:

		Stress, in lbs. per sq. in. for 10 million cycles	
		In Air	In Water
Hot rolled 127,000 tensile	Standard unnotched bar	64,000	34,000
	Bar with square shoulder	36,000	19,000
	Bar with bored hole	31,000	16,000
Quenched and tempered— 166,000 tensile	Standard unnotched	90,000	13,000
	Square shoulder	36,000	11,000
	Bored hole	31,000	9,000

Such data make it seem possible that for parts under repeated stress which have to be notched and which are subject to corrosion, cast iron may be a better material of engineering construction than it has been given credit for being.

To throw some light on the question, unnotched rotating beam fatigue specimens of a Class 50 iron (3.03 C, 1.43 Si, 0.47 Mn, 0.09 S, and 0.17% P, 5200 lbs. per sq. in. tensile, 230 Brinell) was run in Columbus tap water at 1785 r.p.m. and 17,000, 16,000 and 14,000 lbs. per sq. in. The specimen loaded at 17,000 lbs. per sq. in. failed at 5½ million

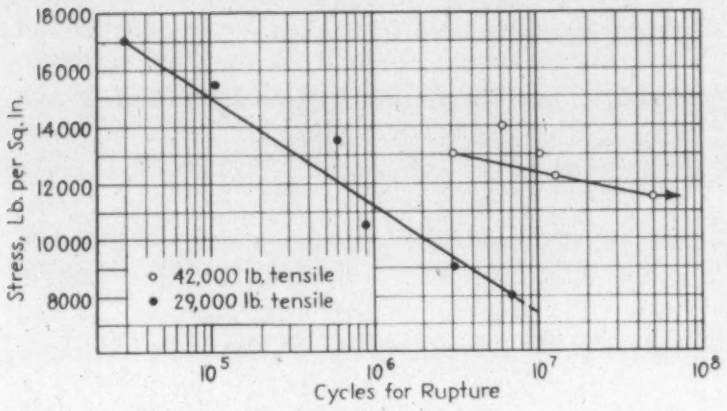


Fig. 1. Fatigue in tap water of two cast irons—1785 r.p.m.

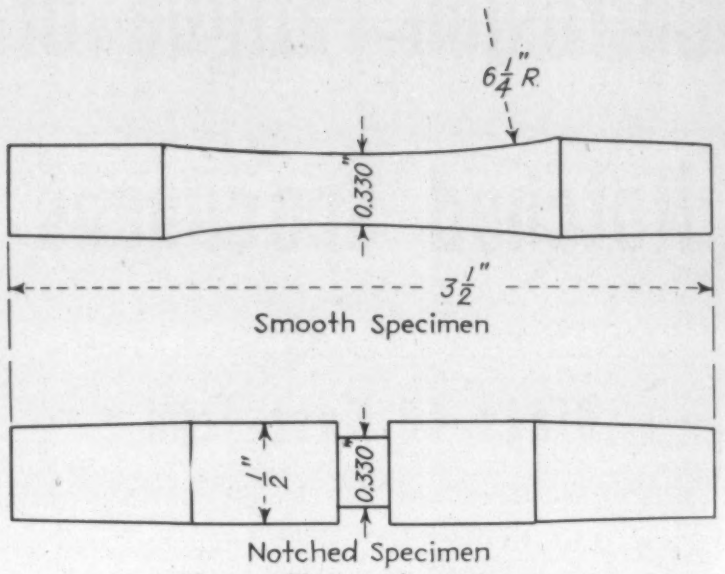


Fig. 2. Types of specimens.

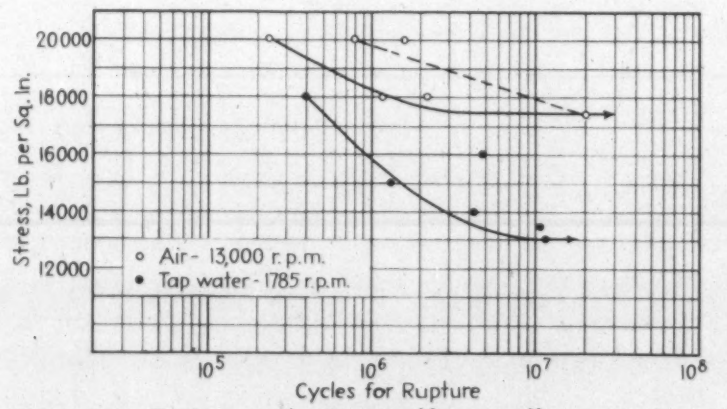


Fig. 3. Fatigue of 40,000-lb. tensile cast iron, smooth specimen.

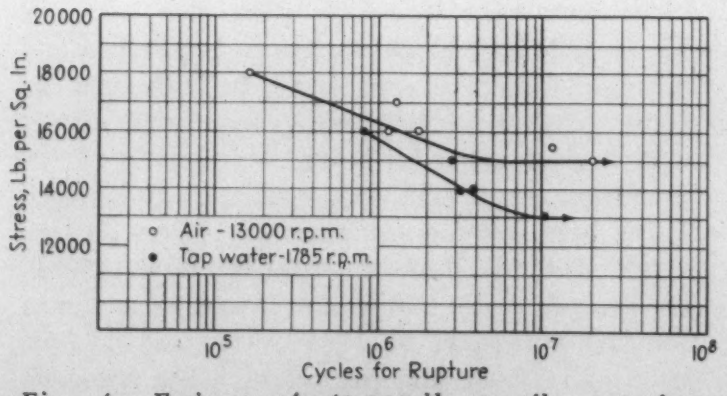


Fig. 4. Fatigue of 40,000-lb. tensile cast iron, notched specimen.

cycles, the one loaded at 16,000 lbs. per sq. in. failed at 21½ million cycles, and the one loaded at 14,000 lbs. per sq. in. ran 55 million cycles without failure. Insufficient material was available for further tests, but these sighting shots seemed interesting.

Two other irons were then similarly studied in corrosion-fatigue on unnotched bars, with the following results:

C	Si	Mn	S	P	Tensile, lbs. per sq. in.	Brinell	Stress, in lbs. per sq. in. for life of 10 million cycles
3.04	2.29	1.04	0.065	0.12	29,000	172	Approx. 7,500
3.00	1.75	1.16	0.073	0.06	42,000	209	Approx. 11,500

The S-N curves are shown in Fig. 1. The soft iron gave low results, but the Class 40 iron was interesting enough to justify further work.

A commercial, cupola melted, Class 40 iron was obtained in sufficient quantity for more comprehensive study. It gave:

C	Si	Mn	S	P
3.42	1.49	0.75	0.10	0.23

Tensile lbs. per sq. in.	Brinell	Endurance limit, lbs. per sq. in. in air	
		Unnotched	Notched
40,000	213	17,500	15,000

Under corrosion fatigue in Columbus tap water at about 1800 r.p.m., the stress for a life of 10 million cycles was: Unnotched—13,000 lbs. per sq. in.; notched, 13,000 lbs. per sq. in. The notch was the Kommers square notch, Fig. 2. The S-N curves are shown in Figs. 3 and 4.

The notched corrosion fatigue stress of 13,000 lbs. per sq. in. for 10 million cycles life, compared with Dolan's figures for SAE 3140, indicates that strong cast irons may not be much inferior to steel under corrosion fatigue in the presence of external stress raisers. The unnotched corrosion fatigue of the 42,000 tensile low phosphorus iron was not as

good as that of the 40,000 tensile, 0.23 per cent P iron, or of the 52,000 tensile, 0.17 per cent P iron used for the sighting shot.

The evidence is insufficient to prove that phosphorus is a factor, but the possibility that it may be a factor is too interesting to ignore. One would not have been greatly surprised, considering the way steels behave, had all the irons shown corrosion fatigue values like those of the soft irons, around 6000 or 7000 lbs. per sq. in.

Since the values of the stronger irons are approximately double that, and since the notched corrosion fatigue is but little below that of unnotched specimens, it is indicated that high test cast irons do have engineering virtues with which they are seldom credited.

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[2] A. V. Karpov. "Fatigue problems in structural designs," *Metals and Alloys,* Vol. 10, 1939, pp. 346-352, 381-388.

[3] D. J. McAdam, Jr. "Influence of stress on corrosion," *Am. Inst. Mining Met. Engrs. Tech. Pub. 417,* 1931, 39 pages.

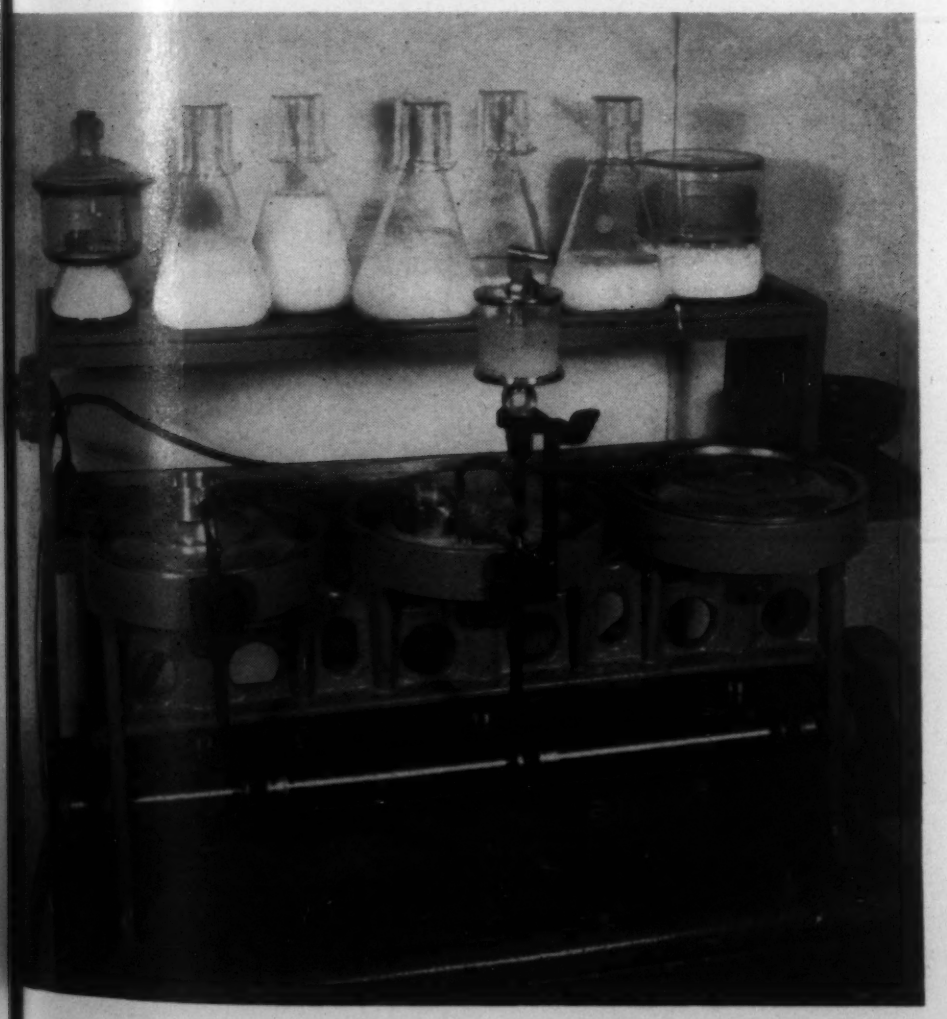
[4] E. Piwowarsky. "Einfluss von Korrosion auf die Festigkeitseigenschaften von Gusseisen," *Z. Ver deut. Ing.,* Vol. 82, Mar. 26, 1938, pp. 370-372.

[5] P. Ludwik. "Kerb- und Korrosionsdauerfestigkeit," *Metallwirtschaft,* Vol. 10, 1931, pp. 705-710.

[6] T. J. Dolan. "Simultaneous effects of corrosion and abrupt changes in section on the fatigue strength of steel." *J. Applied Mechanics,* Vol. 5, 1938, pp. A141-A148.

A Holder for Metallographic Specimens During Polishing

The metallographic specimen holder and the polishing apparatus.

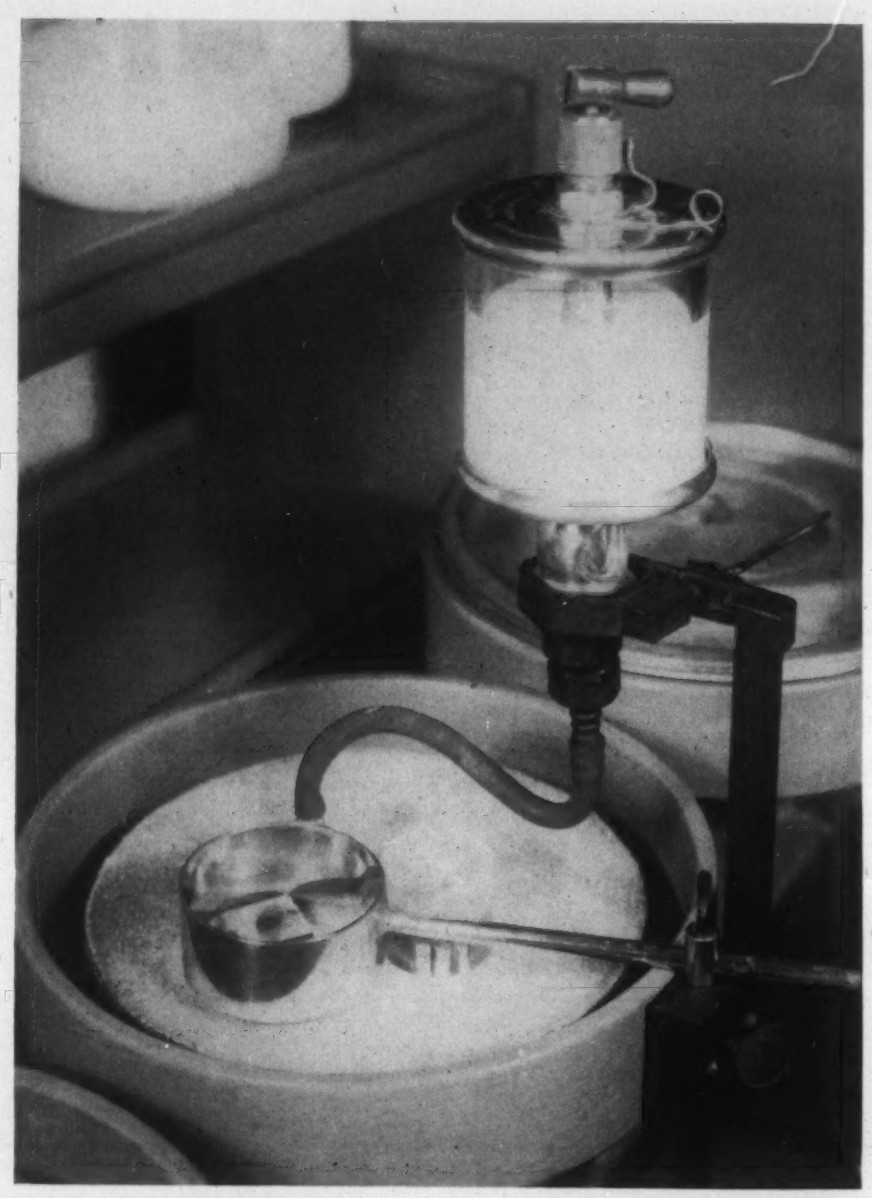


by GEORGE R. KAUFFMAN

Research Laboratories, National Lead Co., Brooklyn, N. Y.

IN THE PREPARATION OF METALS for microscopic examination and photomicrographic work, the final stages of polishing are sometimes done on rotating discs covered with various fabrics with which various abrasives or polishing powders and lubricants are used. As this is a critical stage in the preparation, extreme care must be exercised to keep the specimen flat, cool and free from irregularities. Ordinarily, this entails manual labor and as such is subject to several drawbacks which materially affect the final result.

Primarily, pressure applied through the operator's hand to the specimen may tend to work the surface metal resulting in the appearance of distorted structure on etching. This is particularly true when working on soft metals, such as lead and lead alloys. The second possibility, which is present with all metals, is that of the operator dropping the specimen and causing considerable damage to its surface. Thirdly, the care required for this stage of the preparation is such that the operator can handle only one specimen at a time.



Close-up of the special holder for metallographic specimens.

For this work a simple device has been developed and used with considerable success. The mechanical specimen holder described herein is not only inexpensive but can be readily installed on various types of polishing machines.

This device consists of a thin-walled, circular band of aluminum, 2 in. wide and 2 in. in diameter. This band is fixed to a rod which is adjustable in the horizontal plane and this rod, in turn, is joined to a main supporting bar which is adjustable in the vertical plane. These two adjustments make it possible to fix the band at any position with respect to the polishing disc.

In use, the specimen is placed on the disc and the band brought down over the specimen and about 1/8 in. above the surface of the polishing disc. When the disc is rotating, the specimen is drawn up against the aluminum band and is safely held in one position, with only its own weight pressing against the disc. The polishing is continued at various positions on the disc with the specimen being turned 90 deg. from time to time, until the effects of previous abrasives have been removed. Then the band, containing the specimen, is swung toward the center of the disc and fixed at a position where the specimen, from the drag of the rotating disc, is itself automatically rotated slowly and evenly. Thus, during the final polish on any wheel the specimen, in rotating, provides for the removal of the effects of single direction polishing.

As the lubricant is thrown off, the disc becomes dry and the specimen is subject to the frictional heat developed by the rotating dry wheel. With soft metals this heat can produce appreciable changes in grain size, so in order to prevent this occurring a dropping device is utilized with a rubber tube leading to the side of the aluminum band away from the specimen and through which the lubricant is fed to the disc at a definite rate. This feeder tube being fixed to the aluminum band, the specimen receives the lubrication directly regardless of the position of the band on the wheel.

Different shapes of specimens have been polished successfully with this method, showing that the specimen rotation feature is common to squares, rectangles, and circular specimens. When working with circular specimens this rotation can be obtained by placing a second specimen between the band and the supporting rod, as shown in the accompanying photograph.

(Editorials—Continued from page 141)

for Aeronautics, the Aluminum Co. of America, and some equipment manufacturers, being carried out at Rensselaer Polytechnic Institute. When one considers the billions of rivets to be driven in the defense aircraft production program unless spot-welding can be substituted, and the extra speed and lower gasoline consumption of planes with smooth surfaces against those carrying rivets, it appears that both quantity and quality of aircraft may be vastly increased by successful spot-welding. The problem is not one on which there is no background —a lot of past research and development has brought out specific sub-problems to be attacked. The joint effort is an orderly and sensible way of catching and chloroforming the "bugs" that would crop up in a too-early effort toward commercial utilization.

In the reports on the research work, we may expect some highly technical language in which expert speaks to expert in terms they only can understand, but the result may be planes that speak to Hitler in terms he can understand.—H. W. G.

Electric Steel Capacity

One of the significant developments of the past year in the American steel industry is the increase in electric steel melting capacity. The American Iron and Steel Institute is authority for the statement that "the construction of 21 new electric furnaces has been announced, most of which are already operating or will be by the first of the year. * * * Total capacity of the added electric furnaces is estimated to be at least 900,000 net tons."

This phase of the steel industry is the one that is expanding the most rapidly. With the capacity estimated at 1,882,630 net tons as of Dec. 31, 1939, the new additions will expand this close to 2,800,000 tons, an increase of almost 50 per cent. This is an impressive trend. It is due to three principal causes —greater demand for the stainless steels, increased production of light and medium armor plate made chiefly of electric steel, and expanding use of alloy steels of many types—all influenced markedly by the American Defense Program.

It should be noted that the capacity data, cited above, do not include electric steel foundries—they embrace ingots and only such castings as are made by ingot producers. The electric steel casting industry is by no means a small one and its inclusion in the capacity data would increase this measurably.

The existence of this enhanced electric melting capacity will have a bearing on the ability and willingness of the wrought steel industry to produce "tailor-made" steels when the emergency is over. The movement of the steel industry to provide only the "significant" or present-tonnage alloy steels (editorially discussed in August, 1940) and make it more difficult and expensive to procure an off-the-beaten-track steel for special use or experimental investigation, is thereby made less necessary. The pendulum swings between the extremes of excessive standardization (which can be a strait-jacket) in a sellers' market, and the prevalence of tiny, uneconomic, orders for non-standard special steels, in a buyers' market. Swinging too far either way retards progress. The electric capacity will help to maintain a compromise position that will foster progress. —E. F. C.

letters TO THE EDITOR

Metals and Alloys in the Dairy Industry

To the Editor: In a discussion which is as interesting and excellent as that of Dr. Trebler's "Metals and Alloys in the Dairy Industry," METALS AND ALLOYS, December, 1940, it is somewhat surprising to note the terse three sentence consideration given to "Clad Metal." The entire paragraph is so brief that it may be quoted here:

> Clad metal with a thin layer of 18 and 8 or Inconel rolled together with steel sheet should be ideally suited for large insulated or jacketed storage tanks. It appears, however, that it is still quite difficult to produce satisfactory welds with this type of material, and that the extra cost of the welding when carefully made is almost as much as the saving in the cost of the materials. It therefore seems as if clad metals have no particular place in the dairy industry at the present time, except possibly for table tops and similar uses where no welding is involved.

The writer wishes to point out that the statements in the last two sentences are not consistent with the facts. Composite steels have a considerable background of experience and increasing tonnages are being consumed each year in various industries. In the early days there was difficulty with lack of thorough and uniform bonding between the two metals but this has been overcome in the newer processes which yield a highly satisfactory product, integrally clad.

It is not "quite difficult to produce satisfactory welds with this type of material." A great many shops today fabricate vessels and other parts of composite steel under routine shop conditions, which have resulted from thorough investigation of the welding procedures followed by severe laboratory tests. That welding of these steels is not unduly difficult is borne out by the fact that the fabricator has his choice of several methods of carrying out the welding and that many structures are performing well in service.

The company with which the writer is connected has just completed a detailed series of weld tests upon Pluramelt composite steel, in which the alloy surfaces were of the following compositions: Types 304, 310, 316, 317, 347, 410, 430, and 446. In all cases the weld joint physical properties easily passed the code requirements.

It is concluded by Dr. Trebler that "the extra cost of the welding when carefully made is almost as much as the saving in the cost of the materials." Averagely, a saving of upwards of 30 per cent over solid alloy results when composite metal is used. When more than one bead is required for welding, this is usually carried out by welding from the carbon steel side first with carbon steel rod and then completing the weld by depositing the alloy bead last. Even if the groove is completely filled with the more expensive alloy rod, as is the case when welding double armored composites, it would hardly increase the cost to a point where the saving in base material cost would be obviated.

It may be well at this point to mention that for certain services where heat transfer is a factor the composite steels are preferable to solid austenitic alloys, and that, therefore, this type of material may be particularly desirable in some of the processes of the dairy industry.

Much composite steel is being used in the oil and chemical industry today under severe conditions with excellent results. The increasing use of these steels in other industries is evidence of their utility in replacing solid stainless in certain services.

It seems to the writer, therefore, that contrary to Dr. Trebler's conclusion, integrally bonded composite metals have a definite place in the Dairy Industry, and that, undoubtedly, this industry will use such steel in increasing amount.

H. S. BLUMBERG,
Metallurgist

The M. W. Kellogg Co.
Jersey City, N. J.

Dr. Trebler's Comments

To the Editor: Mr. Blumberg's interesting communication avoids the real issue, namely, what is the actual saving in the selling price of typical pieces of dairy equipment when made from clad metal instead of straight 18-8 stainless and is this saving worth the added risk? It is quite possible that in my paper I put too much stress on the welding difficulties in connection with clad metal but the fact remains that, in spite of many trials by some of the best dairy equipment manufacturers, our industry has not up to now taken very enthusiastically to this type of material.

There may be many reasons for this, the main one being that the dairy industry does not use very high pressure equipment requiring heavy gage material. Another reason is that on account of sanitary requirements, the industry demands exceptionally perfect welding, very high polish and absolute freedom from rust streaks. Also selling expenses are relatively very high because of the large service demand on the manufacturer. All this means that even an appreciable saving in base sheet metal would not amount to much in the final equipment.

The progress which is being made every year in producing and fabricating clad metal is very admirable and we note with interest that its uses in other industries are increasing but I believe that most dairy equipment manufacturers will agree with me that, as far as our particular industry is concerned, the possible savings in the finished equipment costs, so far, have not been worth the added risk.

H. A. TREBLER

Tin Plate and Solder

To the Editor: In a private communication, I have commended my friend, H. W. Gillett, for his very timely and penetrating treatment of the problem of tin plate and solder —from the strategic viewpoint, as published in the November issue of METALS AND ALLOYS.

Mr. Gillett's approach to the problem is particularly useful at this time when there is need for some rational thinking in connection with our *real* need for tin. What he has really said in effect is that our particular type of economy and culture is not in grave danger because of a possible interruption in its normal supply of metallic tin. Any comment that I have concerning his article is in the nature of supplementary suggestions, and inasmuch as he has shown that our container industry is not necessarily endangered, I will not comment upon that particular phase of the problem except to say that I am in essential agreement with his conclusions.

Quite properly, he discusses the important use of tin in soft solder which is so generally employed today in making various sorts of metallic joints and connections.

In the public service industries, including both power and communications, substantial progress has already been made in the amount of solder used by eliminating its use in making certain types of junctures. The experience so far would indicate that these methods could be further developed and elaborated to eliminate still further use of tin-lead solders. I may be mistaken, but I believe that the use of tin in the coating of copper for rubber coated wire can be eliminated. Its use is as much for the convenience of the fellow making the soldered connection as it is for the protection of the copper conductor.

The one extensive use of tin which Mr. Gillett has indicated as a possible need not readily supplied by other means is the wiping solder. I take the liberty of suggesting that if the electrical and plumbing industries were suddenly bereft of a supply of tin-lead solder, they could, without too much travail find a satisfactory substitute. I realize that in recent years' developments in materials for the chemical and related industries, lead has been partially displaced and the art of the lead burner has been in a diminishing demand. I also fully realize that the plumber and the cable splicer would resist the learning of a new art in connection with their trade, but they are resourceful citizens and I am sure that if they were faced with the necessity, they would adapt the lead burners' art to the perfection of their particular structures. I also venture to predict that if this necessity compelled them, once they had accomplished the result, it would be very difficult to get them to change back to the old wiped joint using the standard 38/62 wiping solder.

Mr. Gillett did not treat in detail of one of the minor uses of tin, namely, that of tin bronzes, and I assume that his omission in this instance was intentional because he is too well versed in the metallurgy of bronzes and their uses not to know that for most, if not all, uses non-tin bearing copper alloys are already available or could be made available with relatively little experimental preparation.

I also venture to predict that if the price of tin in relation to the present purchasing value of our currency should long remain at 50 cents per lb., the incentive to eliminate its use on purely economic grounds would continue at an accelerated rate.

In short, if I were vitally interested in enterprises producing metallic tin, I would not be exerting effort so much toward the finding of new uses for tin as I would toward the finding of new and improved methods of beneficiation of tin ores, smelting and refining of tin, to the end that I might be able consistently to market tin below 35 cents per lb. at a profit.

F. W. WILLARD,
President

Nassau Smelting & Refining Co.,
New York

Bearing Metals

To the Editor: METALS AND ALLOYS, December 1940, page 750, states, "1940 Pontiacs are also reported to use lead base babbitts on steel backs." Our comment on this "report" would follow the line of Mark Twain's comment on the report of his death.

Lead-base babbitts have been used on Pontiacs for camshaft bearings for several years, but have never been specified for crankshaft main bearings or connecting rod bearings.

Pontiac Motor Div.,
General Motors Corp.,
Pontiac, Mich.

C. F. SMART,
Metallurgist

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

FORGING AND BENDING PRESSES

New methods and equipment for forging shells, drawing and forming of aircraft sheet components, straightening armor plate, and general press-work on a variety of ordnance products are of obvious and timely interest to metallurgical engineers. In our October 1940 issue, p. 436, we published a description of the very latest practice, employing cast zinc alloy dies for drawing and rubber punches for blanking and forming, in the production of aircraft stampings. Recent developments in equipment for shell-forging, armor-plate-straightening and other "pressing" jobs are reviewed herewith.

Shell-Forging Press

The new and patented Baldwin-Omes mechanical shell-forging press takes a special place beside other mechanical presses coming into use for the production of small-size shells. Manufactured by *Baldwin-Southwark Div. of Baldwin Locomotive Works,* Philadelphia, the new press is a combined piercing and drawing machine and is said to be capable of producing more than twice as many forgings per hour as other type presses.

The piercing operation starts with a *square* billet, an advantage from the standpoint of material-, weight- and cost-saving. The piercing punch enters through a steel guide bushing and expands the billet towards the die walls; the punch is retracted, the die opened and the billet is transferred to one of the two drawing mandrels of the draw bench.

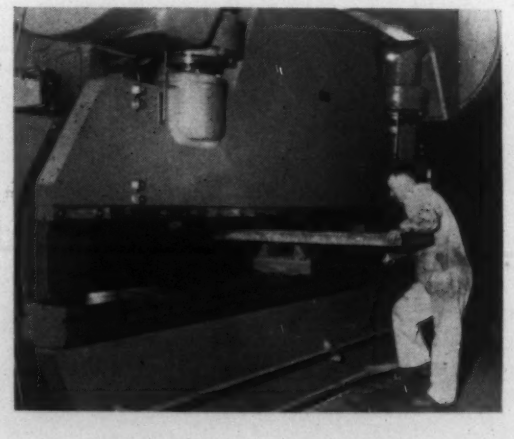
The drawing mandrel crosshead operates in unison with the piercing operation, the mandrels tilting upwards at the back of the stroke to receive the pierced shell, then shift to horizontal to push the shell through 3 drawing rings for ejection at the front of the machine.

Wall thicknesses are described as uniform, reducing outside machining to a minimum. No machining is required inside the shells.

Straightening Armor Plate

The necessity for straightening armor plate distorted during heat treatment has led to the discovery that bending presses are a fast and economical method of hammering the plate back to shape.

According to *Cleveland Crane & Engineering Co.,* Wickliffe, Ohio, several Steelweld bending presses are in such service, usually operating continuously 24 hrs. a day. A typical job is the straightening of 2½-in. armor plate having 170,000 lbs. per sq. in. tensile strength. Tremendous power is required for plate-straightening since the ram of the press hits at full capacity every stroke of the machine; presses run at 20-40 strokes per min. according to plate thickness and upwards of a hundred strokes are required for each plate.



Other Presses

A new hydraulic press for general shop work, featuring a 12-in. screw adjustment and a 12-in. ram stroke, has been introduced by *Charles F. Elmes Engineering Works,* 230 No. Morgan St., Chicago. Operating control is said to be very simple, with maximum accessibility provided through an open-frame all-welded steel construction. A wide range of capacities and sizes is available.

A new 30-ton hydraulic press specifically for pulling work has been developed by *Greenerd Arbor Press Co.,* Nashua, N. H. This press has a 24-in. work-table, and a 2-7/16-in. diam. ram; the work-table is 34 in. above the floor, and the working speed of the ram at 15-30 tons pressure is 38 in. per min.

Castings vs. Welded Construction

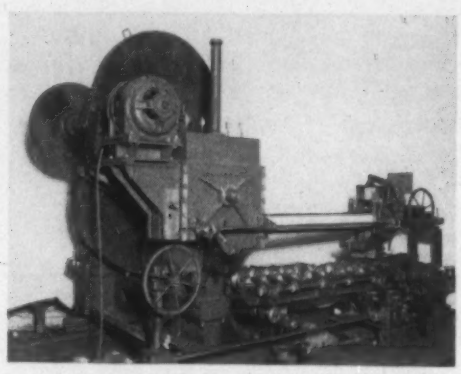
There is no doubt whatever but that in many cases a product can be made in a shorter time and at less cost by welding steel components than by making it of cast iron or cast steel. But there are also a large number of instances in which a product can be made better or cheaper or even faster by casting than by arc welding.

In our October issue we published on p. 481 some data purporting to show the savings in time, cost and weight achieved by fabricating certain specific armament units by welding. It has been called to our attention, however, by the *Meehanite Research Institute of America, Inc.,* Pittsburgh, that statements like "military, naval and aircraft equipment and the machines for making them could be produced in 30% less time [by] arc welding" should not be generalized by the reader to include any more than the specific examples cited, and that even in those cases the superiority of welding is not beyond dispute.

In many cases (particularly in machine-tool manufacture), the Institute points out, *standard* rolled steel shapes cannot be used in the welded structure because of the usually "special" design features, so that somewhere along the line extra time and cost have to be employed to make the special shapes. Where machining of steel components is involved, the much better machinability of modern high-quality cast irons must certainly be considered in deciding how to fabricate. And, of course, such factors as the general quality and durability of the finished product cannot logically be ignored, it is stated.

Hot Billet Shear

For the important problem of shearing alloy steel billets the *Lewis Foundry & Machine Division* of *Blaw-Knox Co.*, Pittsburgh, has developed a vertical-type hot billet shear. The shear, a self-contained accessory that is readily inserted in the production line, cuts downward across the diagonal with, it is claimed, less deformation of the stock through this diagonal action and avoidance of the edge fin so common in flat shearing.



Centralized control permits one man to operate both the shear and the runout table and to retract the table for discharge of the cropped ends. The first unit built accommodates sizes up to 4½ in. sq., and the design is adaptable to larger sizes.

● A new, more viscous lubricant for lathe tail stock centers available from *Chicago Mfg. & Distributing Co.*, 1928 W. 46th St., Chicago, is claimed to save relubrication time, improve precision and make unnecessary the use of high speed steel lathe centers.

Drawing Steel Sheets—Machine for Applying Lubricant

A new coating machine for applying drawing compound to steel sheets before shaping or forming is announced by *Chas. E. Francis Co.*, Rushville, Ind. The new machine is said to make possible a saving of about one-third in draw compound over the hand-brushing method, and to produce considerably more work in shorter time.

The machine consists of two corrugated rubber coating rolls for coating the sheets on both sides, with a doctor or scraper roll used in conjunction with each coating roll. The lower coating roll can be adapted to pick up its supply of mixture from a stationary or adjustable pan. Calibrated adjustments are used for governing the spread, as well as for adjusting the opening between the rolls for thickness of metal.

● Copper tubing with soldered fittings is being widely used for water lines and for air brake lines, particularly on high-speed trains, reports the *Copper & Brass Research Association*, New York. In the latest designs the tube telescopes into the fitting, and the fittings are so carefully machined that the distance between the inner wall of the fitting and the outer wall of the tube amounts to only a few thousandths of an inch. This capillary space sucks up the solder, whatever the position of the fitting, and no pre-tinning is required.

Meetings and Expositions

TECHNICAL ASSOCIATION OF THE PULP & PAPER INDUSTRY, annual meeting. New York, Feb. 17-20, 1941.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, annual meeting. New York, Feb. 17-21, 1941.

AMERICAN SOCIETY FOR TESTING MATERIALS, "Committee Week." Washington, D. C., Mar. 3-7, 1941.

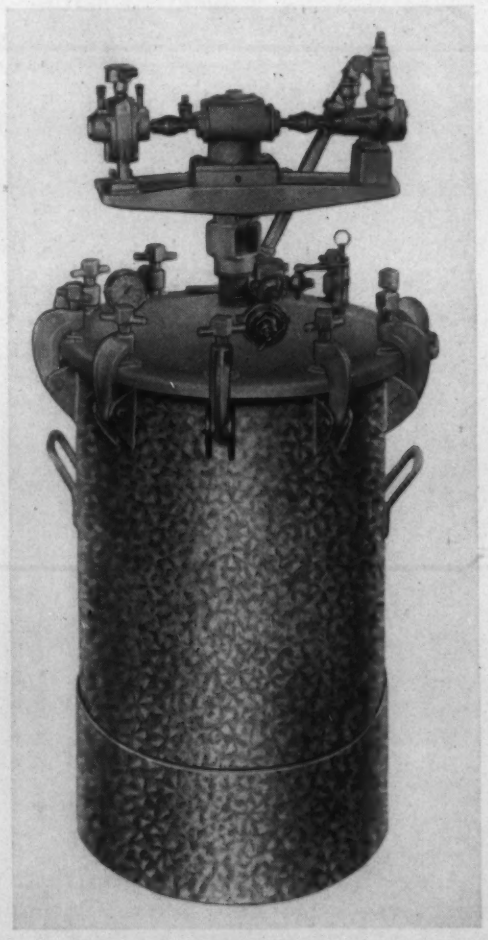
AMERICAN RAILWAY ENGINEERING ASSOCIATION, annual meeting. Chicago, Ill., Mar. 11-13, 1941.

AMERICAN SOCIETY OF TOOL ENGINEERS, annual meeting. Detroit, Mar. 24-29, 1941.

AMERICAN CERAMIC SOCIETY, annual meeting. Baltimore, Mar. 30-Apr. 5, 1941.

Small Paint Circulating Systems

Small manufacturers will be glad to know that *The DeVilbiss Co.*, Toledo, Ohio, has announced the availability of small paint circulating systems that provide, at a cost consistent with limited production, all the economies, safety and convenience inherent in the circulating system of paint delivery.



The new DeVilbiss type QBM small circulating systems will supply a maximum of 6 production-type spray guns in continuous operation handling lacquers, synthetic enamels, paints, varnishes, shellacs, etc. Either air or electric motors are available.

New Temperature Indicator

For many metallurgical engineering purposes it would be highly desirable to have a portable instrument for thermocouple temperature measurements, for checking thermocouples, or for measuring small voltages with somewhat more precision than can now ordinarily be obtained. Such additional precision has now been made available (without increase in instrument cost, by sacrificing the convenience of the reference-junction compensator) in the new 8667 indicator of *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia.

Increased accuracy has been provided by calibrating only a small portion of the range on a continuously adjustable slide wire with the remainder of the range on a dial switch of 10 accurate resistors. The range is from 0 to 111 millivolts with a limit of error of ±0.1 millivolts. The new potentiometer is completely self-contained, light and compact.

● *Acheson Colloids Corp.*, Port Huron, Mich., reports the successful use of Oildag—colloidal graphite in oil—to provide a dry lubricating film on the replacement bearing of a giant fan, the shaft of which had been so badly scored that the bearing failed to hold oil. The Oildag was added to the lubricating oil, and the old shaft and the gradually-tightened bearing "run-in" until at the end of 4 weeks the oil leak had stopped entirely and the bearing was again running cool.

Dolomite Throwing Machine

An improved dolomite throwing machine for making up open hearth banks is offered by *Blaw-Knox Co.*, Blawnox, Pa. Whereas machines of earlier design obtained electric power by plugging in a power cable, the new machines operate under their own power. A diesel or gasoline engine-driven generator provides the power needed to drive the dolomite-throwing mechanism and also to propel the machine along the rails.

Other improvements include the removable hopper, which can be separately hung on the ladle hooks on the floor crane and used to transport dolomite from storage to the open hearth floor; and the availability of various hopper capacities and of divided hoppers.

Personals

Vsevolod N. Krivobok, erstwhile consulting metallurgist for Allegheny Ludlum Steel Corp., and professor of metallurgy at Carnegie Inst. of Technology, is now metallurgist for Lockheed Aircraft Corp., Burbank, Calif. . . . *G. R. Sylvester* has resigned from Allied Engineering Div. of Ferro Enamel Corp. to establish a consulting office under the name of Sylvester & Co. in Cleveland.

Chas. S. Traer has been advanced from vice president in charge of production to president of Acme Steel Co., Chicago. . . . *J. E. Davenport* is now vice president in charge of engineering development and research of American Locomotive Co., New York.

E. J. Appel is to be aluminum production engineer of the new Reynolds Metals Co. aluminum plant at Sheffield, Ala. . . . *A. N. Swanson* has been made chief metallurgist of Gary works of Carnegie-Illinois Steel Corp., Chicago.

George L. Norris, chief metallurgical engineer of Vanadium Corp. of America was tendered a luncheon on Jan. 10th by the company's officers and executives on the dual occasion of the 32nd anniversary of his association with the company and its predecessor, and of his 75th birthday. . . . *Francis M. Turner,* vice president of REINHOLD PUBLISHING CORP. (and managing editor of METALS AND ALLOYS in its earliest days) was entertained at luncheon on Jan. 17th by the officers, executives and veteran employees of this company in commemoration of his quarter-century of service with it.

● *The United States Civil Service Commission,* Washington, D. C., has announced that it will again receive applications for positions of metallurgist and metallurgical engineer (various grades), with salaries ranging from $5,600 to $3,200 a year.

Vertical Combustion Furnace

A new type of electric combustion furnace designed for ease, speed and economy in the determination of carbon, without sacrifice of accuracy, is announced by *Hevi Duty Electric Co.,* Milwaukee, Wis.

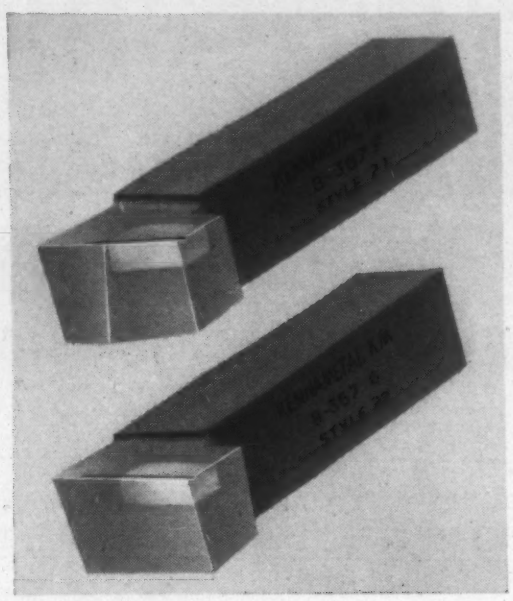
Known as the Sobers vertical combustion furnace, the new equipment has several unique features. A hand-operated elevator is provided for placing the sample in the combustion tube and withdrawing it after combustion. In the center of the elevator is a refractory pedestal that carries the sample in its container (which, incidentally, can be a low-cost home-made common fireclay crucible) to the center of the heating zone, thus avoiding the thermal shock to the combustion tube involved in conventional practice, it is said.

Heating elements are of Alloy 10, and the furnace may be operated continuously at 2300 deg. F., although 2050 deg. F. is a satisfactory temperature for speed and accuracy. The furnace has other unusual and effective features for positioning the elevator platform, sealing and protecting the Sillimanite combustion tube, etc.

It is stated that the furnace can be adapted to the determination of sulphur and to the heat treatment of small delicate parts in protective atmospheres.

New Carbide Facing-Tools

Two new styles of carbide-tipped tools for facing operations in turret lathes have been added to the standard line of Kennametal tools manufactured by *McKenna Metals Co.,* 158 Lloyd Ave., Latrobe, Pa.



Known as Style Nos. 21 and 22, the new tools have 6° side and front clearance angles, 8° end cutting edge angles, 6° side rake and 2° negative back rake. Style 21 has a 20° side cutting edge angle; Style 22 has a zero side cutting edge angle, and hence the latter should be used for facing to a 90° shoulder.

The negative back rake, characteristic of most standard Kennametal tools, has the effect of imparting greater strength to the carbide tip yet without galling. Both tools are supplied with chip breakers, and at the new low prices now in effect.

● An interesting new oil filter, known as the "Ferrofilter," has been developed by *S. G. Frantz Co.,* 161 Grand St., New York, for magnetically removing iron and steel particles from circulating oil systems of machines and engines. The oil flows through a casing enclosing a stack of powerfully magnetized screens, which extract abrasive particles as fine as one micron—particles that might otherwise damage bearings.

Corrosion-Resistant Chain in Pickling

Metallurgical engineers responsible for pickle house operation and maintenance will be interested in reports from the plant of a large producer of steel tubing who has used corrosion-resistant welded chains for over 10 years to carry steel tubing through 6-8% sulphuric acid solutions at 180 deg. F.

According to *International Nickel Co., Inc.,* 67 Wall St., New York, the chains are made of 13/16 in. diameter hot-rolled Monel rods. They are 19 ft. long, and with 2 chains to a crate, they easily carry a load of 8,000-10,000 lbs.

The original reason for installing the Monel chains was their greater safety factor, but the 10-year service has revealed other advantages, it is said. Economy has resulted because the Monel chains provided longer life and fewer repairs.

"Slide Rule" for Sheet Metal Work

The Wolfe angle meter, developed to furnish a method for rapidly laying out directly, on sheet metal or pipe to be cut or welded, any angle of cut from 0 to 90°, is announced by *Interstate Sales Co.,* 1123 Broadway, New York.

Using a method of measuring in both directions from a center line, it requires only 4 measurements to mark a pipe or stretch out in 16 different points on a circumference. Angle measurements can be made in steps of one degree on diameters of 1 in. to 20 in.

The angle meter measures 12 in. by 4½ in. when folded, and is priced at $1.50 for one, down to 90c each in lots of 12.

● Through the bequests of the late Professor William Campbell, two fellowships have been established at Columbia University for graduate study and research in metallurgy. Applications should be filed with the Secretary of the University before March 1, 1941. Two assistantships are expected also to be available in the Department of Metallurgy for the 1941-1942 academic year. For details, write to the Secretary or to Professor Eric R. Jette, School of Mines, Columbia University, New York.

Galvanized Sheet for Paint Bonding

A new type of galvanized sheet, whose surface finish has been metallurgically modified to provide an excellent direct bond for paint coatings, has been christened "Colorbond" by its manufacturer, *Newport Rolling Mill Co.,* Newport, Conn.

Colorbond galvanized sheet is said to provide an anchor for the paint coating, yet its own protectiveness is at least as good as that of conventional galvanizing. According to the manufacturer, not only paint but enamel, varnish, lacquer and other finishes may be used on the galvanized sheet with complete satisfaction. It is emphasized that the surface finishes applied to this sheet do not lose their elasticity or crack, peel or flake off during their surface life.

● Ordinarily magnetic separators are designed to remove unwanted iron and steel particles from non-ferrous borings and turnings. *Stearns Magnetic Mfg. Co.,* Milwaukee, Wis., however, reports the use of a modification of its type "L" separator for reclaiming babbitt from oil chips and turnings left from a rod broaching operation.

Free Service Department

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd St., New York.*

POSITION WANTED: Machine shop foreman or production superintendent on defense work. Night shift and N. Y. City location only. No objection to occasional layoff. Age 34. Draft Class 3. Box MA-2.

POSITION WANTED: Metallurgist, seven years experience in chemical analysis, metallography, physical testing, heat treating, ferrous and non-ferrous foundry work. College metallurgical training, including radiography. Young, married, ambitious American, now employed. Location immaterial. Box MA-3.

*An open message to Johns-Manville Employees**

by LEWIS H. BROWN, *President, Johns-Manville Corp.*

AS THIS NEW YEAR BEGINS, I am glad to have this opportunity to discuss with you the big job facing all of us during 1941.

Because of the demands placed on every business and every citizen by our nation's need for an adequate defense, our work is clearly cut out for us. We must contribute to the utmost of our ability to the defense building program.

Already, one-third of all J-M production is demanded for defense requirements. And this demand is growing daily. Some of it has been due to the increased need for J-M products for direct government projects. Some of it is the result of sales to expanding industries which use our products and are themselves working at top speed to fill government orders.

* * *

With every increased demand Johns-Manville has stepped up production to meet it. Many departments of our seventeen mines and plants have been affected by the defense needs and are now operating seven days a week, 24 hours a day. The working day is divided into three shifts of eight hours. At many locations, four shifts of employees work 40 hours each week to assure full production of the machines 7 days a week. Thus, work on Saturdays and Sundays is distributed fairly among everybody affected.

As the defense program develops we will necessarily have to step up our production more and more. This means we will have to find all the "bottlenecks" and increase the productivity of every machine.

Of course, most of us would prefer that industry's policy could be "business as usual." But these are not normal times. Business cannot be conducted "as usual" in an emergency. Defense comes first.

* * *

As a company, J-M is not going to let anything or anybody stand in the way of expediting the government's efforts to complete the defense program. This means co-operation by all of us, by management and by employees.

Naturally we shall all be called upon to make sacrifices. Taxes will be heavier. Raw material and manufacturing costs will probably rise. We shall all have to bear the burden.

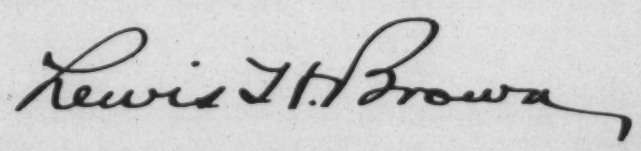
Under these circumstances we shall have to redouble our efforts to reduce waste and increase efficiency so that we not only will be able to deliver quality goods in record time, but keep prices in check. By doing this we shall be helping to keep the costs of the defense program down. As taxpayers we shall indirectly benefit through this economy, for all of us must pay our share of the enormous defense bill.

* * *

There is no doubt in my mind that J-M jobholders can be relied upon to do their part. You have already shown the spirit of real co-operation and patriotism which is so necessary. For your co-operation I want to thank you.

I know that I can count upon your continued support and loyalty in our common effort to help keep this land of ours safe and free.

May I take this opportunity to wish for all of you health and happiness during this new year?



**Although not directly engaged in the manufacture of munitions or armaments, Johns-Manville manufactures many products essential to the operation of industries so engaged. This message, stating Johns-Manville's policy in support of the nation's defense program, originally appeared in the January, 1941, issue of the* News Pictorial, *J-M employee magazine.*

METALLURGICAL ENGINEERING

shop notes

Annealing Deep-Drawn Parts of High-Nickel Alloys

by W. F. Burchfield
International Nickel Co., Inc.

The proper procedure for annealing high-nickel alloys should be carefully established before attempting to carry out this operation in production. Shells should be watched during drawing and should be annealed before the first evidence of over-stressing. Monel and nickel shells should be annealed as soon as any portion shows a Rockwell "B" hardness reading of above 90, and Inconel above 100.

If the original blanks have soft temper, the first anneal for Monel and nickel will be required usually after a total diameter reduction of 45 to 50 per cent. Subsequent anneals should be made after each 30 to 40 per cent cumulative reduction. In most cases this will mean that two drawing operations may be made between anneals.

It is often best to put a few pilot pieces through all operations, with some shells being annealed after each drawing, and the remainder after each two draws. This informs the operator at what stage in the drawing process it is proper to anneal and

Material	Temperature, °F.	Time at Temperature, Min.
Inconel	1700	15 to 20
	1950	2 to 5
Monel	1600	5 to 10
	1800	1 to 4
Nickel	1500	3 to 6
	1700	1 to 4

shows him if the annealing conditions are satisfactory.

As nickel alloys are sensitive to attack by sulphur and oxygen at elevated temperatures the following are to be considered unsatisfactory heat sources for annealing: coal, coke, high-sulphur oil, unwashed producer gas, unwashed blast furnace gas, and any fuel with over 0.5 per cent sulphur content.

Bright annealing is desirable. Sulphur-free city gas, natural gas, tank hydrogen, acetylene, propane, or mixed gases furnish satisfactory reducing atmospheres for Monel and nickel, but dry, pure hydrogen is necessary to produce bright-annealed Inconel. Also, the combustion reactions in the annealing furnace must be fully completed before the gases meet the high-nickel materials, or they will be damaged.

Bright open annealing may be carried out in semi-muffle furnaces in which the fuel (gas or oil) is burned completely in a combustion space beneath the hearth. On withdrawal from the furnace, instead of being cooled in a reducing atmosphere, the shells should be quickly quenched in a solution of 2 per cent or more of alcohol in water.

Furnace atmospheres satisfactory for bright annealing of Monel and nickel produce a green chromic oxide on Inconel. This can be removed readily by pickling. Suggested time and temperatures for open annealing these high-nickel materials are given in the accompanying table.

Thin-Section Casting Losses

by M. L. Carl
Sloss-Sheffield Steel & Iron Co.

Thin-sectioned gray iron castings may find their way to the foundry scrap heap through a variety of causes. We have recently encountered two definite cases of casting losses that were directly traceable to molding sand contaminations.

Sufficient quantities of salt in a sand heap will cause thin-section castings made in such sand to exhibit a vicious type of rust which repeatedly reappears after the casting has been cleaned. The casting surface seems to be pitted deeper than is the case with ordinary rust, and the rust appears in splotches not necessarily covering the entire casting; in fact, less rust is generally found on the heavier sections of the casting. Where a dust-on facing is used on the mold, such rust will appear at the edge of the areas where the sand has peeled off the casting, if allowed to stay in the humid atmosphere of the foundry overnight before cleaning.

Further, the rusty area takes on a purple cast, making one immediately wonder if the dust-on facing might not be responsible, since the rust will appear where the facing has prevented the sand from burning onto the casting. In one case, salt was found mixed with the dust-on facing in one bag of facing, naturally making it appear that the facing was responsible for the trouble, although samples taken from the barrel of facing showed no traces of salt.

The reappearance of rust after air or airless blast-cleaning was noted to take place more quickly than where cleaned by milling, since there remains after milling a film of dry, powdery sand on the surface of the casting, to prevent its rusting for a short time. In the case of air-blasting, it would be easy to imagine there was moisture in the blast, causing the rust, when in reality the salt in the sand is to blame.

Sulphur in the molding sand is another but less frequent cause of trouble. Fortunately, most molding sand producers are careful to see that their sand is shipped uncontaminated and in clean freight cars, but if lump sulphur accidentally gets in the molding sand, there is always the possibility of some of it coming in contact with the casting surface.

Such contact, we have found, causes the casting to have a small indentation, ⅛ in. to ¼ in. in diameter, and of a darker color than the surrounding iron. In some cases, such a pit might not be objectionable, whereas in others it would be enough to cause rejection of the casting.

If sand is suspected of containing salt, it may be very easily checked by a chemist. Sulphur may be missed, however, in taking a small sample, but it can be seen by carefully examining the sand when it is practically dry.

(More "Shop Notes" on page 182)

Tumble-Burnishing Die Castings

by C. R. Maxon
New Jersey Zinc Co.

Since the cost of polishing and buffing die castings to be plated constitutes a considerable part of total finishing cost, any less-expensive substitute is deserving of study. Many plating plants are devoted almost exclusively to plating of die castings, usually of zinc alloy, and not a few of these have attained good results from tumble-burnishing on certain types and grades of work.

Although the quality of finish from tumble-burnishing is not quite equal to that resulting from polishing and buffing, it is adequate for some products and results in marked savings in cost, especially on small die castings—the only type adapted for burnishing by tumbling. Under the best of conditions, the results so closely approximate polishing and buffing that only experts would normally observe such differences as can be detected.

Some platers prefer wet burnishing, which is done in an alkaline solution containing a good burnishing soap and steel balls of such size as to reach all exposed surfaces of the castings being handled. Others employ a form of dry burnishing, using wood-lined barrels in which, besides the castings, various "cutting down" and polishing ingredients are employed.

The wet process may be regarded as somewhat more "messy" and involves, of course, the use of water for which drains must be provided, but it seems to be somewhat simpler and to require, perhaps, rather less attention and skill on the part of those supervising the work. The dry process has certain advantages in cleanliness but presents the disadvantage that small holes may become clogged with the materials used and perhaps involve some extra work in their removal. On the other hand, the best burnishing results which have come to the writer's notice have been secured by dry burnishing.

In either the wet or dry process there are several variable factors that have a bearing on the results and considerable experimental work may be necessary to insure getting optimum results or even such results as will pass muster. Among these are: Size, shape and original finish of castings to be treated; type and proportion of ingredients used, both in respect to each other and to the quantity of castings per batch; size of tumbling barrel and the speed at which it is turned; total time of burnishing and, with the dry process, at least, the relative time in different "cutting down" and finish-burnishing materials.

In wet burnishing, about the same solution is used for the entire job and for many different parts, but the size of balls and the length of time are the chief variables, these depending on the natural surface quality and nature of the casting and the quality of finish required. In dry burnishing, a given shop is likely to employ about the same burnishing compounds for different sizes and shapes of castings, but may vary the proportions of ingredients, the length of time in each and the total time of treatment. Sometimes more and sometimes less abrasive is used and the effectiveness of a given mix varies with its length of use.

As the cost of wet burnishing solutions is low, they are commonly thrown away when the barrel is emptied, but of course steel balls are used repeatedly. A simple rinsing makes wet-burnished castings ready for normal cleaning and plating procedures. With dry burnishing, of course, the castings must be separated from all solid matter, either by sifting or in subsequent cleaning, and this is usually not difficult unless granules of the materials used become wedged in small holes.

Naturally, the smoother the castings treated, the easier and faster is burnishing done. As the flash is rather tough and not very easily broken away by burnishing action, and as "whiskers" also make burnishing difficult, the flash should be sheared as cleanly as possible and without leaving a ridge where the die parting comes if the ridge is objectionable in the finished product. Little if anything can be saved by burnishing if, subsequent to burnishing, any wheel-polishing or buffing is needed to yield the quality of finish demanded.

Please note that we're still shopping for "Shop Notes" and welcome original descriptions of novel or difficult practice, even to the extent of paying hard-earned editorial dollars for them.—Editors.

Recent experience with cast iron distributor gears shows that the addition of molybdenum to iron containing balanced contents of chromium and nickel eliminates the machining difficulty. Transformation occurs during the usual cooling cycle at a temperature that insures sufficient strength and hardness without undesirable carbide concentrations. In one case, highly stressed driving gears are being heat treated to a hardness of 46 Rockwell C.

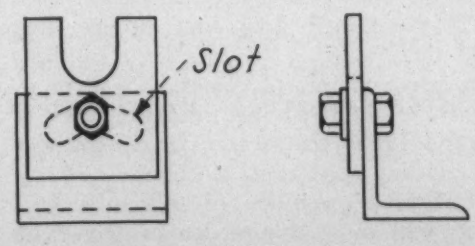
—*Moly Matrix*, Climax Molybdenum Co.

Bar-Holder for Welding

by Rufus Wirth

A very useful gadget for holding a bar at any desired angle for welding can be constructed, as illustrated, from the very simplest material.

In the writer's shop, much of the work consists of welding pads on bars and it was formerly necessary to block them in position. Since this slotted holder was made,



however, the work can be tipped from one side to the other, and will be held rigid for welding in any position.

The holder can be clamped to a bench or other support.

—*The Stabilizer*, Lincoln Electric Co.

"Draw straightening" is a convenient method of handling certain parts which, because of their design, cannot be prevented from distorting in the quench. Generally speaking, if the parts are of a steel that hardens all the way through, they can be successfully straightened by tempering in a fixture. Before clamping up the parts tightly, however, they must be given a draw at a lower temperature than the final draw in order to prevent them from cracking when clamped in the fixture.

—*Heat Treating Hints*, Lindberg Engineering Co.

Cold Forging of Copper

by E. F. Heer

Acheson Colloids Corp.

Cold forging of contact fingers of complicated shape from copper bar stock in a single die-forming operation is difficult because of the tendency of the copper to seize in the die. This difficulty has been overcome in the plant of a well-known electrical equipment manufacturer by the simple method of using a dry-lubricating parting compound for automatically resurfacing the die and punch.

To convert the bar stock into the complicated shape desired, the slug is dropped into a die mounted in a fixture on the platen of a vertical press. A shaped punch is then brought down with the ram of the machine under approximately 300 tons pressure entering the die and squeezing the slug into the proper shape.

Alongside the press is a tray containing "dag" colloidal graphite suspended in oil (made by Acheson Colloids Corp., Port Huron, Mich.). The slugs are dropped into this tray and acquire a coating of the colloidal graphite prior to being placed on the loading chute. The colloidal graphite, transferred from the slug to the surfaces of the die and punch—under the pressure and friction of the coining operation—forms what is known as a "graphoid" surface on these parts, preventing metal-to-metal contact in the die and eliminating pick-up and sticking.

The condition of this surface is maintained by the colloidal graphite carried into the die by each succeeding slug. The graphoid surface itself has no measurable thickness and thus does not affect the dimensions of the finished part. Excess graphite is carried off by the finished part.

With this development, ejection of forged parts prevents no difficulty. The process incidentally has resulted in a surprisingly low die and punch wear, probably attributable to the presence and constant renewal of the graphoid surface. Production of contact fingers by this method at the rate of 350 per hr. has been accomplished.

In extruding aluminum, trouble with packing wear and scoring of heat-treated (up to 700 Brinell) steel for hydraulic pistons on the extrusion dies can be minimized by using "K" Monel pistons, which are adequately hard, yet rust-proof.

—*Inco*, International Nickel Co., Inc.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Core Ovens

"Modern Core Ovens." H. M. Lane (Paul Maehler Co.) *Iron Age*, Vol. 146, Oct. 17, 1940, pp. 42-45. Practical.

In the usual practice core strengths vary from 4 to 5 lbs./in.^{2} up to as high as 150 lbs./in.^{2} Oil binders are best baked between 425° and 450° F. Water-soluble binders containing corn starch, molasses, glue, etc. are baked at 350° F. Pitch and resin binders are baked at 400° F.

During baking the heat must raise the core plates and sand to baking temperature; raise the moisture (about 6% of the sand) to its boiling point; evaporate the moisture and oxidize the oil in the core binder. The oven must be heated uniformly or these reactions may take place at the same time in different parts of the oven. The oven atmosphere must have enough oxygen to oxidize the binder. A large amount of air is needed and it must be recirculated for economy.

In the early ovens, the coldest point was 2 ft. away from and 250° F. cooler than the hottest point. To correct this, mechanical methods of heat distribution were used. An important step in the evolution of the modern oven was the use of a fan for exhausting the gases and a form of recirculation that took some of the gases from the outlet flue and introduced them into the inlet flue beyond the fire. The oven floor was then depressed to the bottom of the fire flue, and this increased the efficiency considerably. At the same time core oils made with rosin oil were introduced, which evaporated from the cores and caused fires in the flue. Small fans were used in the bottom of the flue to induce draft.

This design was improved by building fire boxes in back of the ovens above the floor and using natural draft. When oil was used the burner was placed at one end of the flue; in a large oven, the burner was placed at the end of the trenches under the center of the core car along the oven walls. The most common arrangement when gas was used was a long perforated pipe on each side of the oven. Air under pressure was used to bring the gas through. Coke oven auxiliary air ovens gave the best results because of the greater amount of hot gases circulated.

The greatest efficiency has been produced by an oil- or gas-fired air heater. This unit develops constant hot air at moderate temperatures. Efficiency is enhanced by properly designed air and recirculating ducts, and separate venting system. The air-heat system has no pits or firing trenches and the oven floors are flush with the foundry floor. VSP (1)

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CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT CO.
Main Office & Works AMBLER, PENNA.

1a. Ferrous

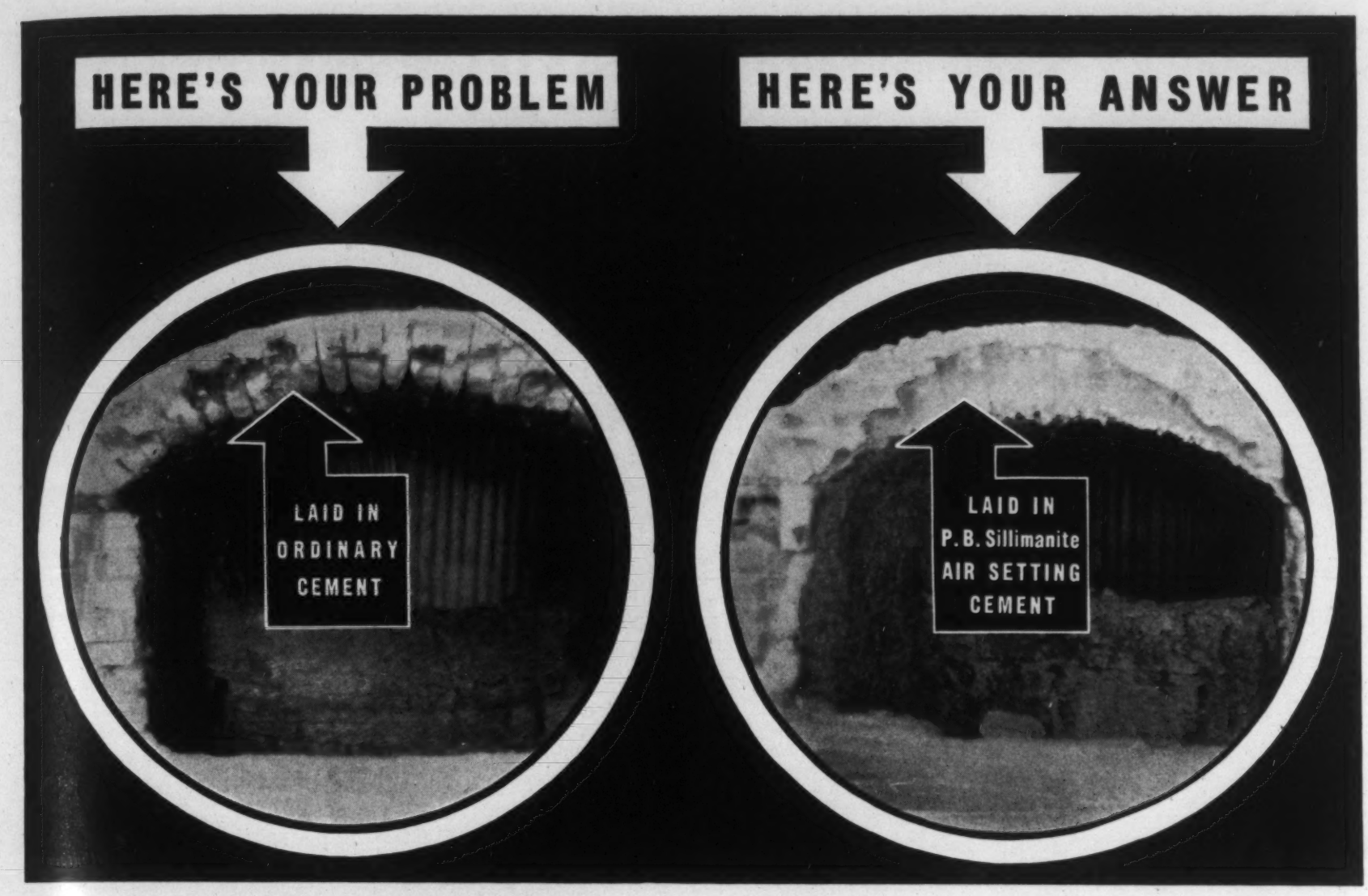
Scrap in the Blast Furnace

"Effects of Scrap in the Blast-furnace Burden." C. L. T. Edwards (Bethlehem Steel Co.) *Metals Tech.*, Vol. 8, Jan. 1941, T. P. 1270, 6 pp. Practical.

In partial answer to the question "Is iron made with scrap in the blast-furnace charge as good iron as that made without scrap—made with straight ore?" the author cites the fact that the open hearth men of the Bethlehem Steel Co. who used pig iron from a blast furnace operating on *100% steel scrap* found no difficulty (other than that resulting from the difference in analysis) in making highest quality forging steels from such iron.

The high steel-scrap burdens were employed in 1919 primarily to utilize some 22,000 tons of badly corroded alloy steel turnings and borings. The furnace employed had a 16-ft. hearth, 22-ft. bosh, 15.5-ft. stock line, 11.5-ft. bell and a Baker-Neuman top. Substantial improvement in operation would be expected if the practice were repeated today.

The physical quality of the iron from 100% steel scrap was so little different from that normally expected from 100% ore that no one paid any particular attention to it. In practice, the increase in scrap proportion was accompanied by decrease in



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That P. B. SILLIMANITE Air Setting Cement will do the job is shown in these photographs of the arches over port snouts or port intakes of a continuous flat glass furnace. The arch bonded with P. B. SILLIMANITE Air Setting Cement was used for the 1st or "hotter" ports. The clay bonded arch was used for the 3rd or "cooler" ports—less batch carry over, too.

Operating efficiency is impaired by ragged, open joints, as cavities increase the number and area of exposed brick surfaces or area, resulting in shorter life and higher heat losses.

Easy-to-use P. B. SILLIMANITE Air Setting Cement reduces spalling hazards and a host of other brickwork ailments which can be traced to ordinary cements. Specify P. B. SILLIMANITE Air Setting Cement today and you'll soon agree that "here's your answer." Write for more information.

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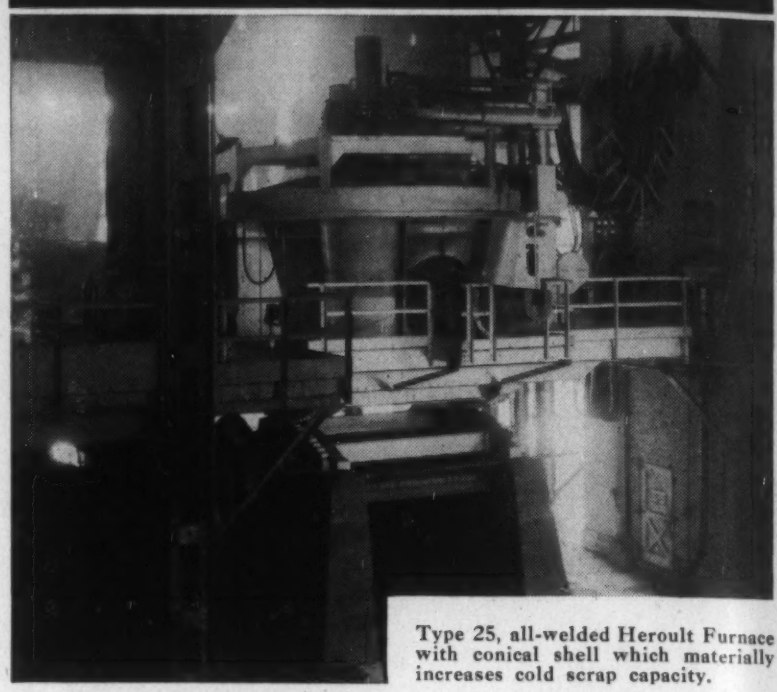

Type 25, all-welded Heroult Furnace with conical shell which materially increases cold scrap capacity.

For low-cost, efficient melting and refining of all kinds of ferrous materials by either basic or acid process—including alloy, tool, and forging steels, iron and steel castings. Any capacity from ½ ton to 100 tons; hand, chute, machine or drop-bottom bucket charging.

AMERICAN BRIDGE COMPANY

General Offices: Pittsburgh, Pa.

Offices in the larger cities

Columbia Steel Co., San Francisco, *Pacific Coast Distributors*

United States Steel Export Company, New York

UNITED STATES STEEL

top temperature, and with 100% scrap the stock line was dropped 12 ft. below normal to keep the top temperature above the dew point.

The daily log showed no undue blast pressure until the swing-over from 100% scrap back to normal ore burdens, at which time the charge hung up severely. The remedy for this seems to be, when switching from scrap to ore, to maintain the lowest stock line permitted by top temperatures until the last charge of steel turnings has been digested, after which a reasonable charge of fuel should be made for preheating, and the furnace then filled to the normal stock line.

The use of scrap must be controlled if pig iron analyses are to be anything but random. For example, the effect, on the metallurgy of the furnace, of a shift from steel scrap to cast iron scrap may be as marked as the switch from a basic ore mixture to a foundry ore mixture in normal practice.

The charging of scrap into the blast furnace is not a "cupola operation," for the carrying of a normal blast furnace slag is necessary, and thus makes this a smelting rather than a melting process. As the percentage of steel scrap in the charge increases, the slag volume per ton decreases, thereby drying up the mix.

The process is fundamentally flexible, since it can be used to make good pig iron out of high-sulphur cast iron scrap and heavily oxidized steel borings that as direct scrap additions to the open hearth would constitute a difficult problem. There appears to be no fundamental reason for any difference in the qualities of pig irons produced from ore and from scrap. When differences do occur, they are complementary with the nature of the materials involved, and such variables are inherent in ore mixtures, just as in mixtures that include scrap. (1a)

Rust Protection in Steel Mills

"Steel Dips into New Coatings." Harry D. Kolb (Penola, Inc.) *Blast Furnace & Steel Plant,* Vol. 28, Nov. 1940, pp. 1069-1072. Practical.

The use of rust-inhibiting coatings is a regular practice on all steel-mill products susceptible to rusting during delivery. Thin, light-bodied liquids with the consistency of kerosene are normally used for sheets or strip. For other steel needs heavier products are provided ranging up to heavy solids that must be heated to be applied. Where production methods warrant it, flow-coating machines are used to apply the product. Dip tanks are common for many applications.

Roll-necks should be coated, as soon as they are taken out of service, with a product of a plastic consistency which can be applied by hand, using a brush or paddle. Special adhesive and tacky coatings are required for this service. All rust preventive compounds designed for temporary protection should be readily removable in petroleum or other solvents. Those intended for sheet or strip should also be removable by vapor degreasing and other commonly used cleaning methods.

Special coating oils that form hard, varnish-like transparent films are designed primarily for use where a durable, non-removable protective film is desired. They are usually a combination of a volatile solvent and certain drying oils. They are most generally used on pipe, but are applied also to structural shapes, plate, castings, and manufactured parts. They may be sprayed, dipped or brushed like paints. Special machines have been built for pipe coating.

Standard accelerated tests have been devised by the author's firm to test the effectiveness of coatings. Normally, small sand-blasted steel panels are used. In the indoor storage test coated panels are placed in a cabinet through which air passes at the rate of 12 ft.³/hr. This air is maintained at 100% humidity, heated to 100° F., and directed into the cabinet against baffle plates, which insure uniform air distribution. This test gives a good indication of the merit of products used for indoor or protected outdoor storage, where humidity and temperature variations are the main corrosion factors.

Water-spray tests are used also, and for full outdoor exposure, the best protection will come from a product that rates well on both the humidifier and water-spray tests. MS (1a)

Open-Hearth Manganese Losses

"Manganese Losses in Open-Hearth Practice." *Foundry Trade J.,* Vol. 63, Sept. 12, 1940, pp. 175-178; Sept. 19, 1940, pp. 191-192. Review of research by Bardenheuer & Henke originally published in *Stahl u. Eisen.*

The function of manganese in open-hearth steelmaking, and particularly the losses sustained and means for their reduc-

tion, are examined and discussed. In open-hearth charges, manganese is partially oxidized and passes into the slag; its distribution between charge and slag is in a definite ratio, which is determined by the temperature and the composition of the slag.

According to Bardenheuer and Thanheiser, increasing the temperature of the charge and the basicity of a slag (not previously purely basic) results in deoxidation of the bath by carbon and also favorably influences the recovery of manganese from the small quantity of slag formed. Manganese has to maintain the steel bath low in oxygen only towards the end of the decarburization period, since before this point is reached the highly reactive carbon will determine the oxygen concentration.

It does not appear economical to have large quantities of manganese present in the charge at the very outset, for the greater part of the manganese passes into the slag during melting, and must be reduced again and induced to pass into the molten metal. This final transfer of manganese, however, is definitely limited, since according to the present experimental data only about 15% of the total initial manganese in the charge is again recovered from the slag by reduction. A higher initial content of manganese in the charge will thus always result in increased loss of the metal, even when the maximum quantity is recovered by slag reduction.

It is far more important to melt down the charge with sufficient carbon, and to keep the oxygen value of the charge low by prolonged and active boiling. High manganese recovery can hardly be realized when the charge is melted too slowly. In addition to the absolute amount of slag, the slagging reaction itself also has an important bearing on the reduction of manganese from the slag. The quantity of slag formed, and hence the degree of recovery of manganese, is also affected by the refining action of the furnace.

Under suitable melting conditions, it is sufficient to have 0.8% to 1% Mn in the charge to ensure a steel containing 0.4-0.5% Mn and to dispense with the final addition of ferro-manganese. [*This would be true only on high carbon steel.*—C. H. H.] For counteracting oxidation losses during tapping, the following method is satisfactory: The ladle is raised to be almost horizontal in line with the lip of the spout so that the metal can flow into the ladle with little change of direction and without breaking up the stream into individual jets. As the metal collects in the ladle, the latter is slowly lowered so that the minimum gap is retained between the end of the spout and the level of molten steel in the ladle. AIK (1a)

1b. Non-Ferrous

Rolling of Magnesium

"The Rolling of Magnesium." W. R. D. Jones & L. Powell. *J. Inst. Metals*, Vol. 66, Sept. 1940, 18 pp. Research.

Cast slabs of magnesium were hot-rolled into 10-gage sheet. These were then reduced to 16 gage by a combination of hot rolling and cold rolling, so that the finished sheets received 0, 5, 10, 25, 50, 75, and 100% cold extension. The sheets were annealed at 32, 212, 400, 575, 750 and 930° F. (0, 100, 200, 300, 400, and 500° C.) Tensile test pieces were made transverse, longitudinal, and at 45° to the direction of rolling. Hardness and cupping tests and grain-size counts were carried out on the sheets.

The mechanical properties in the direction transverse to rolling were higher than those in other directions, and the difference became more pronounced as the amount of cold work increased. Small amounts (5% extension) were harmful and the bad effects were not removed by annealing at temperatures as high as 930° F. This can be explained by the fact that the hot-rolled material was coarse-grained.

For sheets rolled with 10% or more cold extension the effect of annealing was practically identical for each degree of reduction. With 10-30% cold extension the directional properties were eliminated by annealing at 575° F. With greater amounts of cold work directionality persisted after annealing at 930° F.

Annealing at 212° F. was sufficient to diminish the results of heavy cold work on the ductility, but a very marked increase in ductility took place on annealing at 575° F. Higher annealing temperatures lowered the mechanical properties. Grain growth commenced on annealing at 212° F., but the temperature at which pronounced growth occurred was 750° F. and the grain size was further increased by annealing at 930° F. The greater the amount of cold work the higher was the resulting hardness, but an annealing temperature of about 575° F. resulted in a softening to a value which was practically the same in all cases. JLG (1b)

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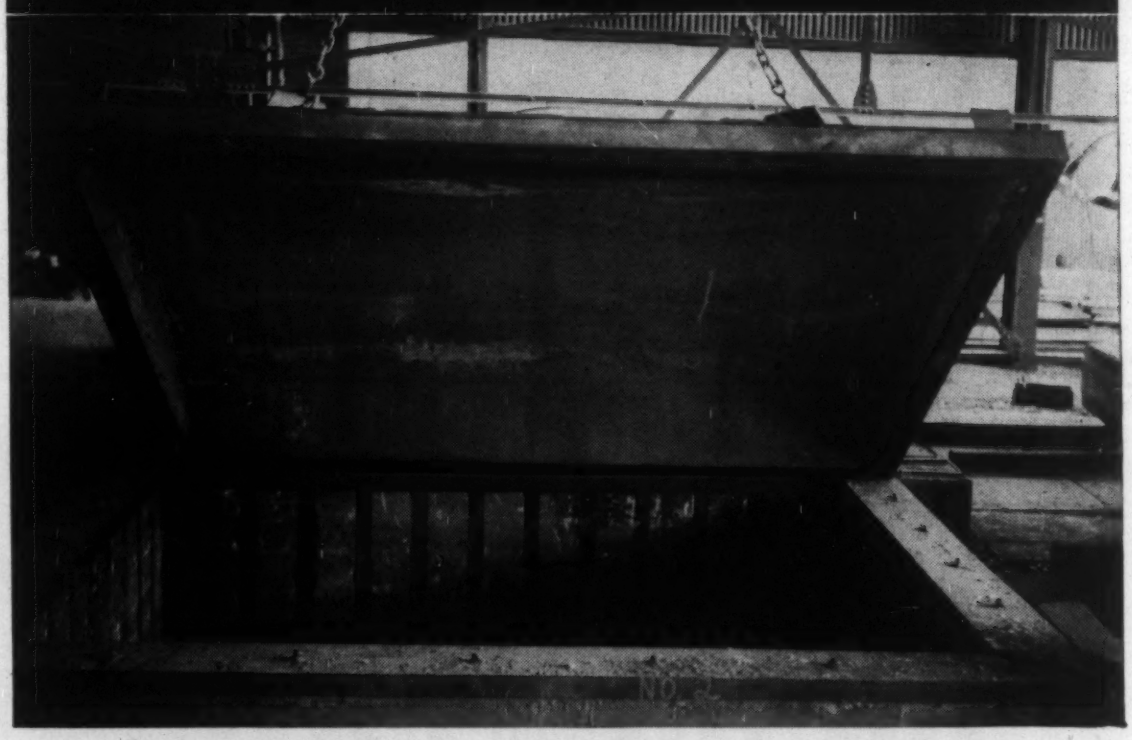

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LUMNITE FOR REFRACTORY CONCRETE

Cold-Chamber Die Casting

"Cold-Chamber Die Casting." Herbert Chase. *Iron Age*, Vol. 146, Nov. 28, 1940, pp. 31-34. Descriptive.

The cold-chamber process is the only one suitable for copper-base alloys and for magnesium alloy die castings. It is advantageous for aluminum alloys, especially if the part is to be used in aircraft. As yet, however, zinc alloy castings are not made by this process.

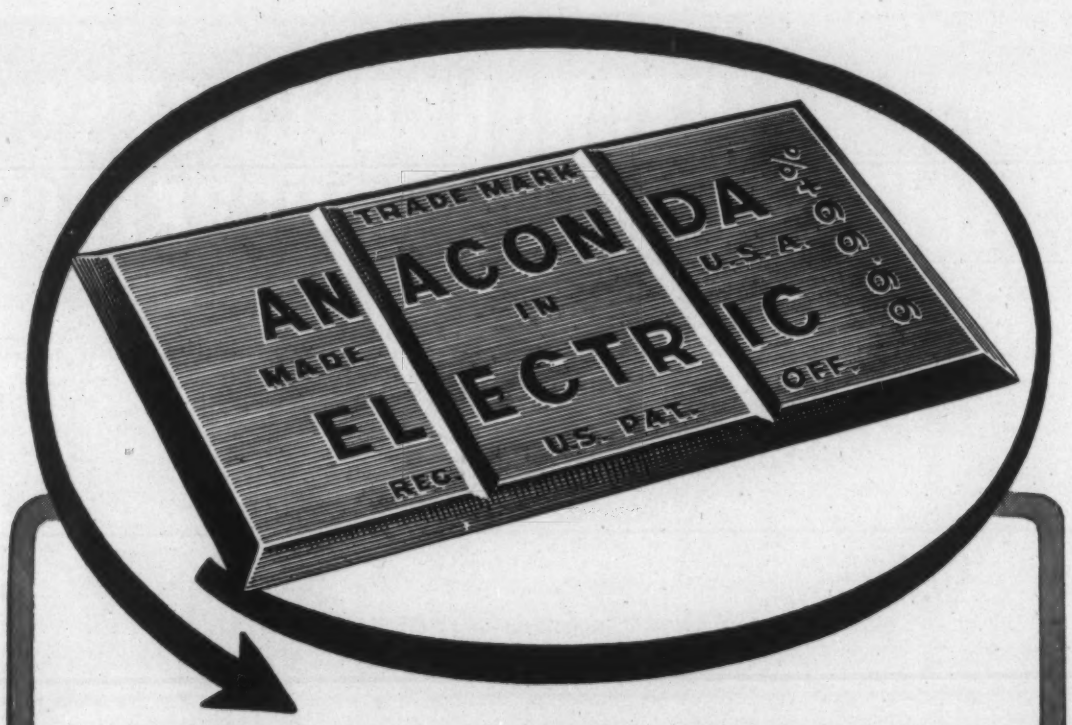
The practice of the Harvill Aircraft Die Casting Corp., which uses this process extensively, is described. The machines used are designed by the company itself. A hydraulic toggle mechanism is used for locking the dies of a hydraulic plunger for forcing the liquid metal into the dies after the metal is ladled into the cold chamber. The pressure seldom exceeds 12,000 lbs./in.^{2}

The metal is heated in pots separate from the machine so that the metal is held close to its melting point, and sometimes in a semi-molten condition. The metal is ladled by hand in roughly measured quantities into the cold chamber, after which the ram forces the metal into the die. Excess metal forms a slug attached to the casting gate, and is broken off and remelted. With magnesium it is necessary to use a special hood over the melting pot and apply sulphur in such a way that sulphur dioxide is formed above the metal and air is excluded, to avoid ignition of the metal. A small amount of flux is also added, and the metal is ladled from below surface. Aluminum alloys are handled similarly, except that provision against entrance of air is not required.

Casting rates vary with the size and section thickness of the casting. An average of 500 die fillings per 8 hr. is usually accomplished. Because of short-run work, which is the rule in aircraft, die costs are reduced by using chromium-nickel-iron sand castings for dies, and casting cavities to within 1/8-1/4 in. of required size, allowing enough extra metal for machining. Average die cavities are cut in slabs of chromium-vanadium steel, which is cyanide-hardened. For die casting alloys of high melting point high speed tool steels containing about 12% W and 4% Cr are used.

Copper alloy die castings are said to have tensile strengths as high as 110,000 lbs./in.^{2} These are used for Diesel engine parts and some for machine tools. One of the largest aluminum alloy die castings made for aircraft is a control pedestal produced in 2 parts weighing 4 lbs. Small parts produced from magnesium alloys include junction boxes and bomb release parts. Aluminum die castings are produced in larger number and greater diversity of sizes and shapes.

VSP (1b)



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99.99+% ZINC

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Natural Gas in a Brass Foundry

"Brass Foundry Practice." R. M. Richter. *Industrial Gas*, Vol. 19, Dec. 1940, pp. 5-6. Descriptive.

Completely successful large-scale application of natural gas in brass-foundry operations is reported by a Los Angeles plant making plumbing fixtures, valves, fittings, etc., much of it of 85-5-5-5 red brass. Gas-fired equipment includes two 60-in. diam. refractory-lined 1-ton capacity Hawley-Schwartz melting furnaces, 2 ladle heaters, the core oven and the water tube boiler.

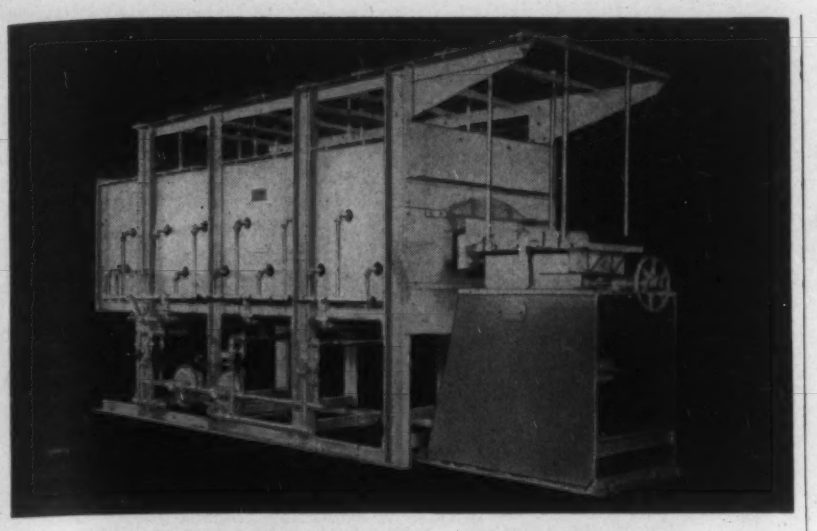
A few major changes were necessary to convert the Schwartz furnaces for natural gas firing; these were accomplished without difficulty and at a conservative cost. Gas burners were installed to proportion the air and gas in correct ratio. The 2 burner ports were enlarged from 2 in. to 3 in. by installing 3-in. i.d., 8-in. straight side refractory tiles as burner tunnels. A 5-in. gate valve in the air line and a 2-in. lubricated plug valve on the gas end are wide open during firing, throttling being handled with a proportioning valve.

The total charge (1400 lbs.) comprises 50% ingots, 30% gates and 20% borings and filings; the latter are passed over a magnetic separator to remove iron particles. Additional zinc is added after skimming and 10 min. before pouring to make up for volatilization. Pouring temperature is 2150° F. A slightly reducing atmosphere (1% CO) is maintained in the furnace during heating.

Twenty minutes is ordinarily needed to draw and pour a charge from one of these furnaces. After pouring, the furnace is rotated a quarter revolution on its horizontal axis, the loading door swung open and in less than 10 min. a new charge is weighed and introduced and the furnace again tilted into firing position.

The use of natural gas reduced the heating time per charge from 70 min. to about 50, and fuel cost was reduced from $1.35 per heat to 76 cents—the actual saving being $68./month. Gas consumption varies from 2.13 to 2.96 ft.^{3}/lb. of brass melted, the minimum being attained by recharging a hot furnace promptly after pouring.

FPP (1b)



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Your work (stampings, forgings, wire products, etc.) is conveyed by its own momentum through a reciprocating full muffle whose strokes are variable in number, length and force to suit the shape, size and weight of the work pieces.

Efficiency is of the highest since work only leaves the machine, and heat losses and maintenance incident to belt conveyors are eliminated.

Why not investigate this fundamentally different clean hardening machine?

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NEW EXOTHERMIC AGENT FOR ALLOYING STEEL AND IRON WITH CHROMIUM IN OPEN HEARTH OR ELECTRIC FURNACES AND BY LADLE ADDITIONS.

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Preventing burn-in of mold and facing materials in pouring white hot metals...

THE MERIT MARK OF METAL — TAM

HOW A TAM PRODUCT INSURES CLEAN CASTINGS OF HIGHLY ALLOYED STEELS

The burning in of mold and facing sand where metal is poured at abnormally high temperatures is a constant source of increased cleaning costs. This is particularly true of highly alloyed steel castings—and is accentuated where the casting has fine detail such as internal threaded cores.

TAM Foundry Zircon Sand offers a practical method for preventing embedded sand, and the subsequent labor of chipping and cleaning. Highly resistant to extreme pouring temperatures, TAM Foundry Zircon Sand does not warp, requires a minimum of venting, yields clean, smooth castings with practically any type of metals—nickel-chrome steels, 18-8 stainless steels, in fact, with any of the highly alloyed steels . . . Can be used for the entire mold or as a facing sand, backed by ordinary sand . . . Has high reclamation value.

TAM Foundry Zircon Flour, used as a mold wash where ordinary flours tend to burn in, is another valuable adjunct to better foundry practice. Full particulars on request. Titanium Alloy Manufacturing Company, Niagara Falls, N. Y., U. S. A.

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for better metals

2 Processing and Fabrication

FORGING, FORMING, MACHINING HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

Fabricating Pre-Finished Metals

"Fabricating Pre-Finished Metals." Carl C. Struever (Am. Nickeloid Co.) *Steel*, Vol. 107, Nov. 25, 1940, pp. 52-54. Practical.

The ultimate aim in using pre-finished metals, plated with nickel, chromium, brass, or copper, is to avoid finishing the work after forming. Most pre-finished sheets have a zinc-base and are more readily workable than the more commonly used alloy sheets. As the ductility of zinc-base metals fall rapidly below 70° F., both the metal and the forming tools should be warmed to 100° F.

Bends should be made "against the grain." An ordinary brake or forming roll is usually used in bending. The bending and clamping jaw should not be sharp, to avoid scratching the metal. A little radius should be allowed in bending and should be increased as the metal thickness increases. Inserting a piece of paper between the upper and lower leaf or covering the polished surface of the pre-finished metal with paper will overcome scratching.

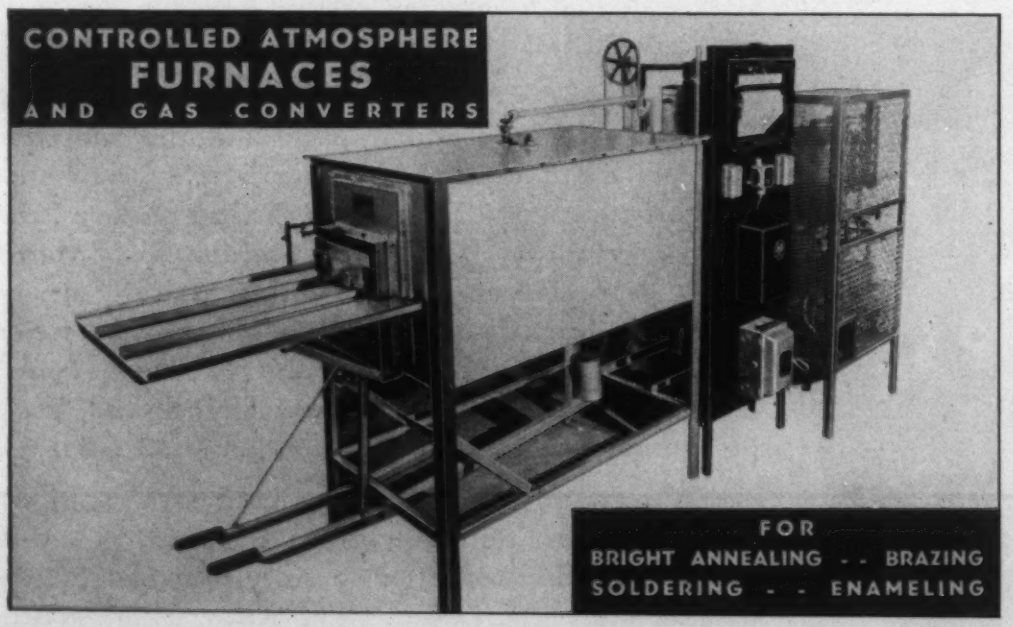
In soldering, the surface should be carefully cleaned. The flux used is the customary hydrochloric acid and zinc dippings. Half and half solder, free from antimony, is used with a moderately hot iron while the surface to be soldered is still moist with flux. A heavy soldering-iron is preferable, and no heat should be imparted to sheet.

Soldering directly on a chromium finish cannot be done satisfactorily. However, the chromium can be removed easily on the area to be soldered by scraping with a sharp 3-cornered tool with hydrochloric acid applied with swab or brush. The dissolved chromium is wiped off, and a paste flux and solder is then applied in the usual manner.

All drawing operations should be done at 70° F. or above. No annealing between draws is required. For ordinary small stamped parts, soapy water and oil drawing compounds are satisfactory. If the metal is not oiled, then the cutting edge of punch and die should be scrubbed with oil occasionally. For large areas, a heavy oil or grease is used.

Paper-adhered surface on pre-finished metals is valuable in preventing handling scratches and also aids in getting better results from severe drawing and forming operations. In setting-up machines and tools, allowance for paper thickness should be made—about 0.0025 in. Chromium plating the dies will reduce surface scratches and die marks to a minimum. Brass, copper, tin and steel-base metals are worked like zinc-base metals in many respects.

Many tests on spot welding pre-finished metals showed that a steel base is most successful. Elkonite welding tips are used, with a special mushroom tip on the bottom contact and a fairly sharp rounded nose tip on the upper. To prevent injury to the surface, just sufficient current to make the weld should be applied. MS (2)



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Aluminum-Bronze Welding

"Aluminum-Bronze Welds." W. B. Scott (Ampco Metal Inc.) *Steel*, Vol. 107, Nov. 11, 1940, pp. 56, 58, 60. Descriptive.

A series of aluminum-bronze welding rods, new from the standpoint of the flux coating, has been developed. The properties of the weld-metal made from the various grades vary from Rockwell B hardness of 63, ultimate tensile strength of 61,500 lbs./in.^{2}, and 24.5% elongation in 2 in. for "Grade 12," to Rockwell C hardness of 38, ultimate tensile strength of 96,000 lbs./in.^{2}, and 0.5% elongation in 2 in. for "Grade 22." Individual grades are used for welding cast iron and steel parts, and non-ferrous alloys, with either oxyacetylene flame or electric arc; for repairing castings, or for overlays where the size of the casting and application prevent the economical use of cast aluminum-bronze; for surfacing forming and drawing dies on carbon and stainless steels, where freedom from scratching and galling is desired; on long-run forming dies and where deep draws on heavy gage stock are involved.

3 WAYS TOCCO JUNIOR Helps Speed Defense Production!

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For new high-speed army tanks, TOCCO Junior hardens SAE 1045 track pins, ⅜" diameter, at 1½" per second. A long carburizing cycle is eliminated. This is but one example of how TOCCO cuts heat-treating hours to seconds.

Two hours after one TOCCO Junior reached a receiving platform, it began turning out 100 Rocker Shafts an hour hardened at six areas per shaft. The self-contained TOCCO Junior requires only power and water connections for installation. It fits a machining line with ease.

Four weeks from date of order, a TOCCO Junior should be in your plant ready to reduce surface-hardening costs and step up production. Original cost of the TOCCO Junior is competitive with standard heat-treating furnaces.

The speed, accuracy and economy of the TOCCO MG 10 Junior is unsurpassed by other forms of surface hardening. TOCCO's Process of Localized Induction Hardening hardens at the *wearing surfaces only,* uniformly and with accurate control of the metallurgical structure. TOCCO Junior handles a variety of parts in long or short runs...can be used for annealing, brazing or soldering... has pre-set full automatic controls and a *built-in* high frequency motor generator set. The Junior is available in several models with one to three hardening stations and with fixtures easily changed.

TOCCO Junior answers your need for speed.
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Parts are Now Used in Uncle Sam's
AIRPLANES • GUN MOUNTS
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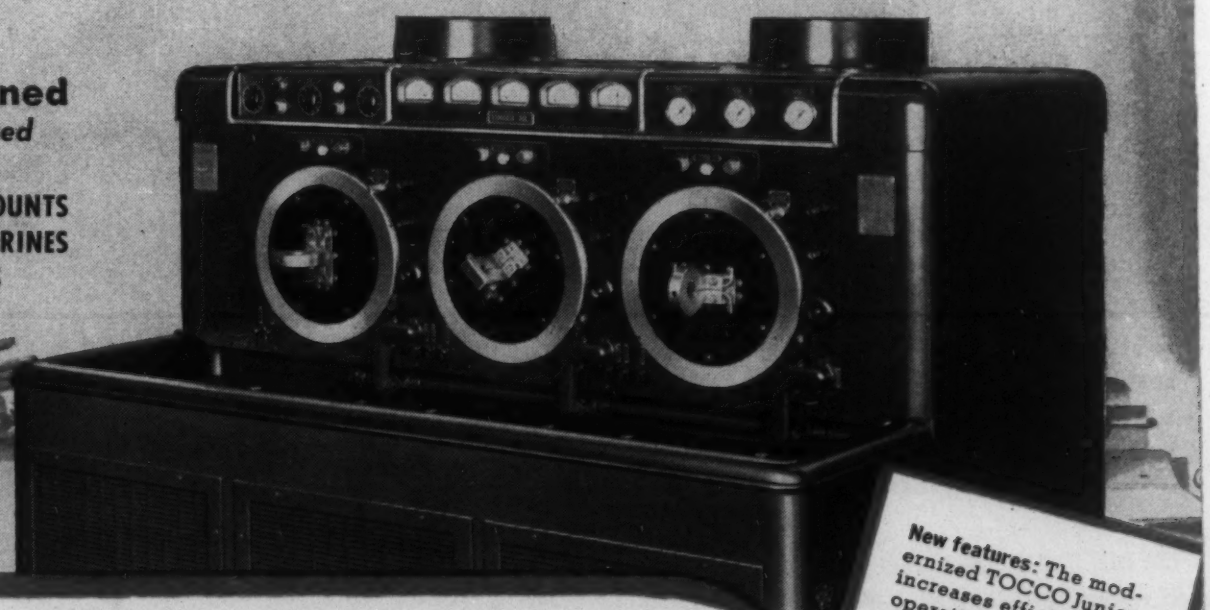

New features: The modernized TOCCO Junior increases efficiency of operation; transformer panels can now rotate to adjust position of inductor from horizontal to perpendicular; controls are all at eye level; exhaust fans are placed on top; and water manifolds and controls are located immediately above work pan.

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"Why Heat Treat the Whole Piece?"

Oxyacetylene welding requires only local preheating to a high cherry red. Welds are generally stronger than the base metal. If the surface of metal upon which the aluminum-bronze is to be deposited is heated almost to fluidity, the weld metal will flow freely and good fusion will result.

In oxyacetylene welding non-ferrous metals, the work must always be done in the forehand position, using a neutral-to-slightly-oxidizing flame. The welding rod should be melted by the outer envelope flame, and the inner core should never come in contact with the rod because a low temperature is best for it. The usual gas equipment can be used. Thorough ventilation of the welding enclosure is recommended.

In metallic arc welding, the length of arc must be kept constant and the rod applied at a steady rate of speed. The proper length of arc is determined by electrode size and the material being welded. Wherever possible, a "figure 8" movement of the electrode should be used. Reverse polarity is recommended in metallic arc welding. At the end of each bead, the craters formed can be entirely filled by shortening the arc until the rod itself short-circuits against the work.

In carbon-arc welding, straight polarity is always used and the rod is fed into the arc stream formed between the base metal and the carbon electrode. The rod is fed into the weld in a manner similar to that employed in the oxyacetylene process. Generally, low-carbon steels that may be welded readily require no preheating. Steels with 0.30% or more carbon require preheating. Should the weld become brittle due to rapid cooling, this can be corrected by reheating to a maximum of 1400° F. followed by furnace cooling for small sections or by air cooling for large sections.

In welding wrought iron or cast iron, an electrode no larger than 3/16-in. diam. should be used. Current should be held as low as possible, and only about 2 in. of weld deposited at any time, followed by thorough wire-brushing. In overlay welding of cast iron, 2 layers should be applied to provide an overlay of sufficient thickness if machining is required later, so that the finished surface will fall within the outer layer. Shorter arc and correspondingly lower voltage should be used in overhead welding than in downhand position. MS (2)

Electric Resistance Brazing

"Electro-Brazing Methods." R. J. Wensley (I. T. E. Circuit Breaker Co.) *Welding J.*, N. Y., Vol. 19, Oct. 1940, pp. 754-758. Descriptive.

In electric resistance brazing, brazing alloy in the form of sheet 0.003 in. thick is placed between the piece of copper or other metal to be brazed and heated under pressure by carbon blocks carrying a high (alternating) current of low voltage. A flux is applied to the surfaces to be wetted by the brazing alloy; the flux in melting protects the surfaces until the brazing alloy has melted.

The pressure is applied during the melting and after the current is turned off, and is maintained until the alloy has set. Grease, cutting compounds, etc. must first be removed in a hot trichlorethylene or other degreasing bath.

The materials brazed include copper, bronzes, brasses and steels as well as special electrical contact materials. The most difficult to braze are aluminum bronze and lead brass, since both form insoluble oxides that the regular flux will not remove.

Contacts made of compressed blocks of silver and graphite powders are brazed directly to copper supports by this method. Other contacts of molybdenum and silver powders briquetted to shape are difficult to wet with brazing alloy because of the ineffectiveness of the flux on the oxides of molybdenum. Wetting of such contact material is possible only by rubbing a stick of the brazing alloy vigorously over the heated surface of the block. WB (2)

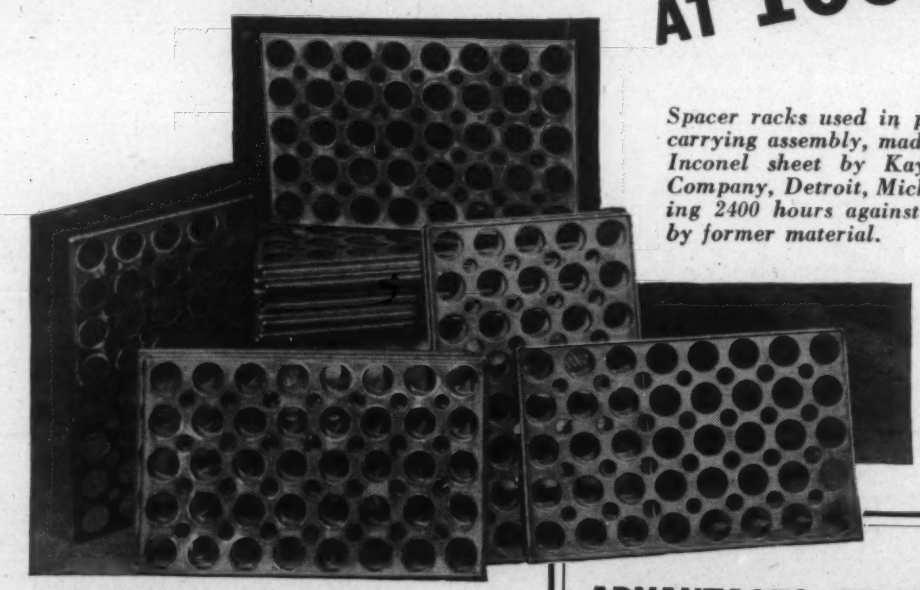
3600° F. Resistor Furnaces

"High Temperature Metallic Resistor Furnaces." W. Kroll. *Trans. Electrochem. Soc.*, Vol. 79, 1941; Preprint, 14 pp. Descriptive.

The well-known limitations of the conventional nickel-base or iron-base resistor alloys with respect to temperatures available led to the study and development of metallic-resistor furnaces large enough for plant practice and capable of producing temperatures up to 3600° F.

The furnace can be operated continuously. Several types have been built, using resistors of tungsten wire or ribbon, molybdenum wire, or a molybdenum-tungsten (10% W) alloy, together with refractories of zirconia, thoria or alumina, and, of course, a hydrogen atmosphere to protect the resistor. The most important applications envisaged are for sintering molybdenum and tungsten bars and firing ceramic bodies.

INCONEL 2400 VS. 700 HOURS AT 1650° F.



Spacer racks used in pinion gear carrying assembly, made from 1/16" Inconel sheet by Kay Products Company, Detroit, Mich. Now giving 2400 hours against 700 hours by former material.

. . . Withstands entire carburizing process . . . followed by quenching!

For carburizing, nitriding and other heat-treating equipment, have you investigated the possibilities of the high-nickel alloy INCONEL?

Note the advantages of Inconel as listed at right. For full information on this heat-resistant, high-nickel alloy write for Bulletin C-8, "High Temperature Uses of Monel, Nickel and Inconel". Address:

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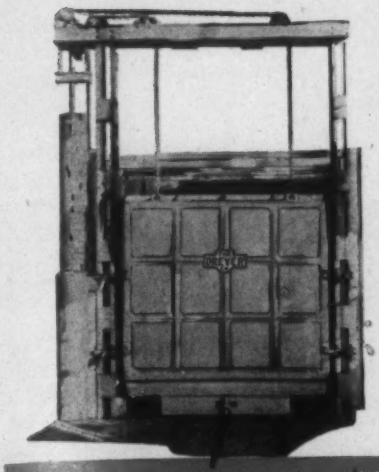
"Inconel" is a registered trade-mark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately 80% nickel, with additions of chromium and iron.

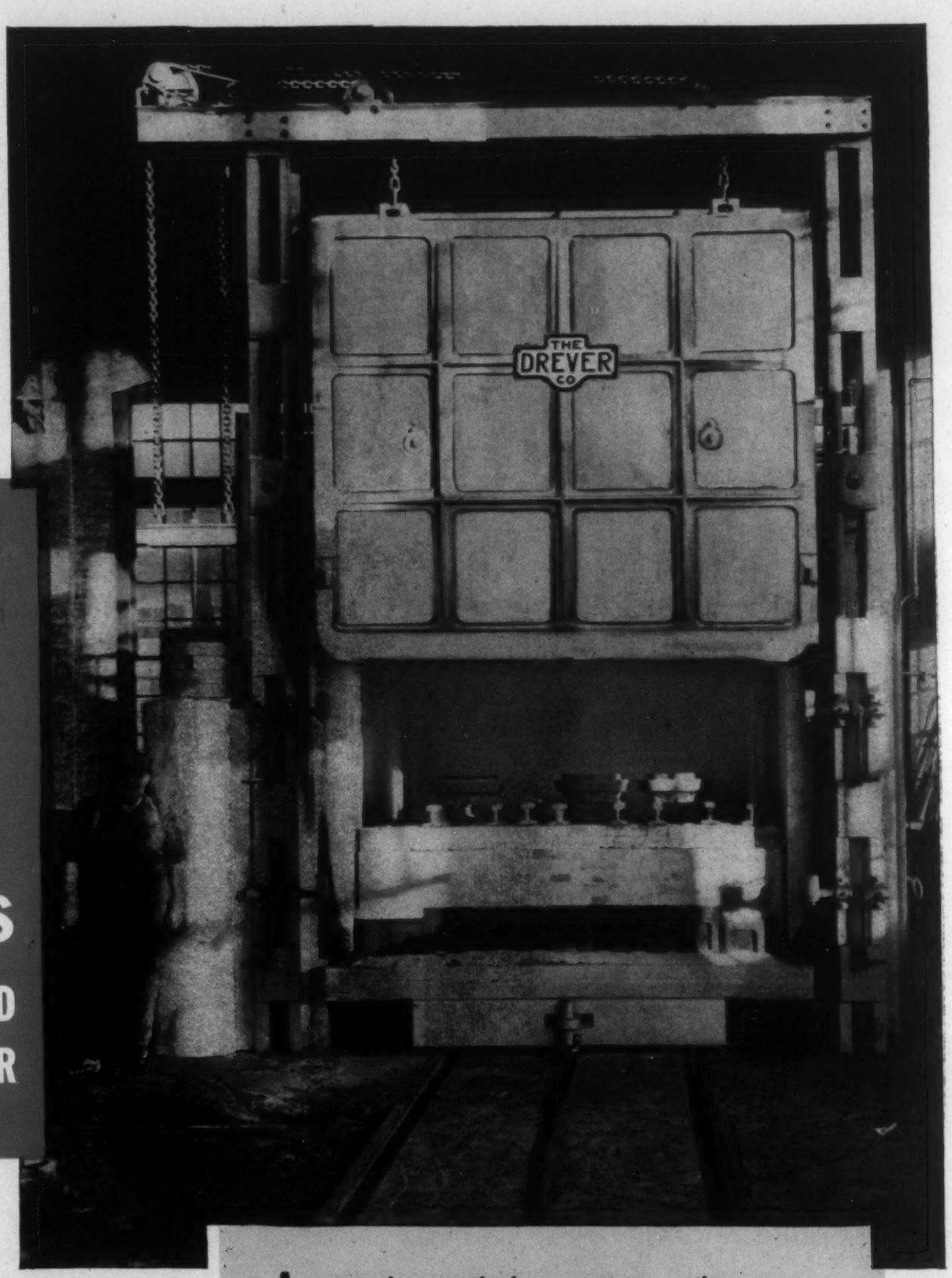
ADVANTAGES OF INCONEL AT HIGH TEMPERATURES

1 Maintains high strength and ductility.
2 Very resistant to oxidation. Oxide adherent, does not readily scale off.
3 Resistant to carburization.
4 Resistant to the effects of nitriding gases.
5 Resistant to hydrogen, cracked ammonia and other protective atmospheres.
6 Makes ductile welds, not subject to intergranular deterioration.
7 Free from excessive distortion during sudden temperature changes, due to low coefficient of thermal expansion.
8 Readily formed into complicated shapes.
9 Mill forms and welding rod available from mill stocks.

INCONEL INCO HIGH-NICKEL CHROME ALLOY 80—14



DREVER CAR-TYPE FURNACES DESIGNED AND BUILT TO ORDER



The assurance of peak furnace performance begins with the design—which must reflect the conditions peculiar to your heat treating problem. The Drever Company, builders of specialty furnaces, combine all the factors involved to meet your most exacting specifications. You can depend on Drever—Furnaces of all types for the Heat Treating of Metals.

An extremely versatile furnace giving uniform, controlled temperatures to 2000°F. for Annealing, Carburizing, heating for quenching, and a wide variety of heat treatments—especially those requiring long cycle times with maximum production efficiency.

Oil fired through the car (underfired) giving quick, but gentle heat . . . manifolded flues with automatic damper assures close control of atmosphere pressure in heating chamber . . . automatic sand seal in rear of furnace . . . height of chamber above car, 4′ 4″.

Details of Car: **8′ 10″ wide; 16′ long . . . anti-friction bearings and accurately machined parts for easy movement . . . car (and door) can be motor driven.**

This is but one of a number of Drever-designed and Drever-built electric or fuel fired car-type furnaces in operation to meet specific production requirements.

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760 E. VENANGO ST.
PHILADELPHIA, PA.

. . . Designers and Builders of Specialty Furnaces

The highest-temperature type of furnace provides for free expansion of a freely suspended rugged resistor (composed of 6 U-shaped 0.13-in. diam. and 16-in. long tungsten rods whose ends are fastened between 2 water-cooled copper blocks by pouring the copper around the wire-ends). The chamber "walls" are a molybdenum tube backed with about 2 in. of crystallized alumina powder. The furnace shell also is water-cooled, and the furnace cover supports the copper blocks and 6 resistor wire-ends. The height of the heating zone is about 15 in.

This furnace requires about 14 kw. to attain a resistor temperature of 3600° F. and a furnace temperature (both measured with a disappearing filament type of optical pyrometer) of 3100° F. FPP (2)

2a. Ferrous

Controlled Atmospheres

A Composite

Protective atmospheres for heating metals and particularly for heating steels without decarburizing or oxidizing the surface, have become the subject of as much research, development, purchase orders and plain ordinary argument as any phase of metallurgical engineering. Instigated chiefly by the type of data on controlled atmospheres published by Gillett and by Gonser and Slowter in this magazine in 1935, 1937 and 1938, waves of new atmospheres, generators, furnaces and purifying systems have recently been developed and installed—all presumably based on the now-accepted principle that carbon dioxide and water vapor may be as generally harmful as is oxygen itself.

Disillusionment there has been a-plenty with much of the equipment claimed to protect "steel" simply and cheaply from decarb and scaling. As the ensuing paragraphs demonstrate, there are also some very good, nearly fool-proof atmospheres available, but what metallurgical engineers still need more than anything else is a cheap, unencumbered protective atmosphere, made from ordinary fuel gases, that will be neither decarburizing nor scaling to a wide range of steels and over wide ranges of temperature.

Worth-while appraisals of our present position with respect to controlled atmospheres are provided in two recent publications. In the first—a symposium on "Furnace Atmospheres for Metallurgical Purposes" presented before the Division of Gas and Fuel Chemistry of the Am. Chemical Soc. in Detroit last September and published in *Ind. & Eng. Chemistry*, (Ind. Edition) Vol. 33, Jan. 1941, pp. 23-59—current practice and research trends are reviewed in 6 papers.

General Behavior and Equipment

In "Chemical Equilibrium and the Control of Furnace Atmospheres: A review of Equilibrium Data," J. B. AUSTIN & M. J. DAY (U. S. Steel Corp. Res. Lab.) review the literature on furnace atmosphere equilibria and present data on the following reactions:

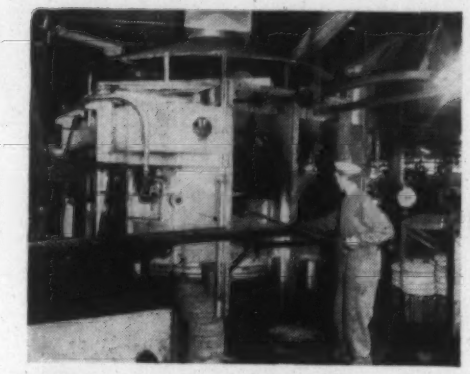
$$Fe + H_2O = FeO + H_2$$
$$Fe + CO_2 = FeO + CO$$
$$CO + H_2O = CO_2 + H_2$$
$$CO_2 + C = 2CO$$
$$CH_4 = C + 2H_2$$
$$Fe_3C + CO_2 = 3Fe + 2CO$$
$$Fe_3C + 2H_2 = 3Fe + CH_4$$

Equilibrium data of this type are expressed quantitatively by the law of mass action. It is emphasized that in some gas reactions the partial pressures of the reactants alone determine the direction of the reaction at a given temperature but in other cases the total pressure of the reacting gases must also be taken into consideration.

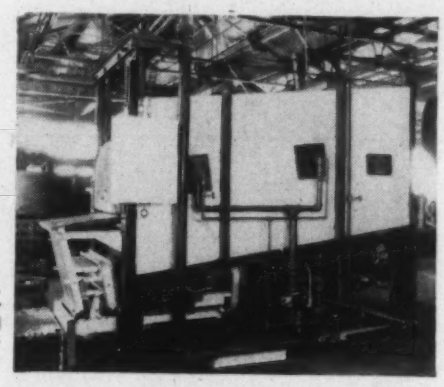
The presented equilibrium data are correlated with various examples where it is pointed out that the rate of gas flow through the furnace may have an appreciable effect on the results because of non-equilibrium conditions. Undesirable reactions on heating and cooling are shown to be possible even when the atmosphere is satisfactory at the heat treating temperature. The difficulties of obtaining data for determining furnace equilibria are recognized in the statement ". . . the proper analysis of a furnace gas is not at all easy and there are no completely satisfactory continuous methods for general use."

In "Producing Annealing Atmospheres From the Products of Combustion of Gaseous Fuels," A. G. HOTCHKISS (Gen. Elec. Co.) discusses the development of controlled atmospheres by the partial combustion of carbon-containing gases or cracked ammonia. Composition and cost charts are given for various fuels.

Several impurities must be removed from controlled atmospheres for certain uses. Water vapor is removed by condensation, refrigeration or chemical driers. Sulphur is removed by water, iron oxide or activated carbon. Nitric oxide need not be removed so long as the oxygen content of the atmosphere is held below 0.75%. Carbon dioxide is usually removed by amine solutions.



An EF Oil Fired Rotary Heat Treating Large Forgings.



An EF Continuous Pusher Heating Small Billets for Forging.

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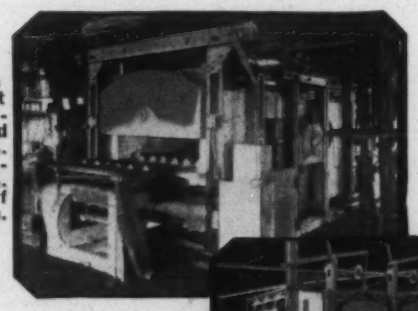

Continuous pusher billet heating furnace. Reduced fuel cost 50%. Increased production 100%. Paid for itself in four months.

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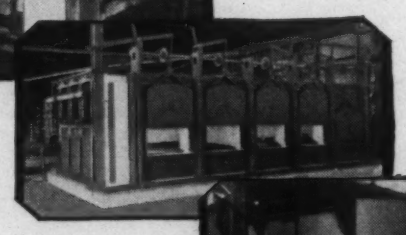
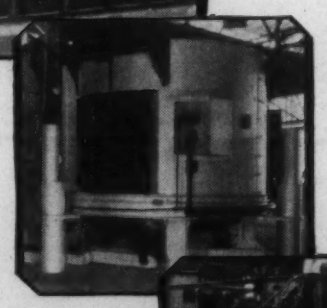
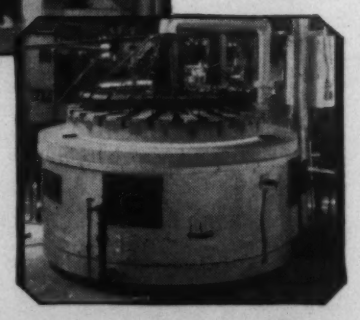


A fuel fired batch type forging furnace for large and unusual shapes and sizes — for intermittent production.



Rotary hearth forging furnace. Increased production from 30 to 60 forgings per hour. Decreased fuel cost 60%. Saved 10c per forging.

(Below) Gas fired rotary end heating furnace. Increased production over 100%. Replaced four old style furnaces.



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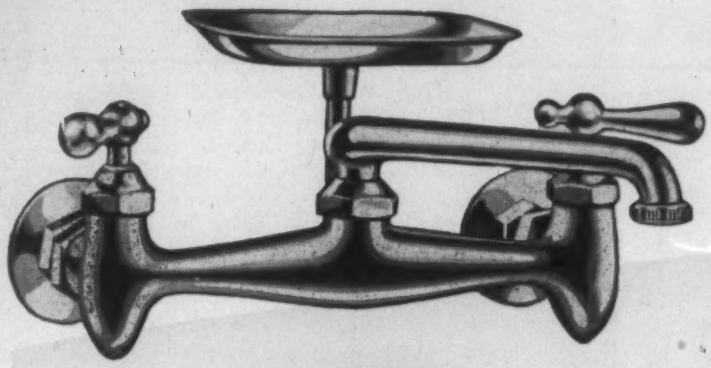

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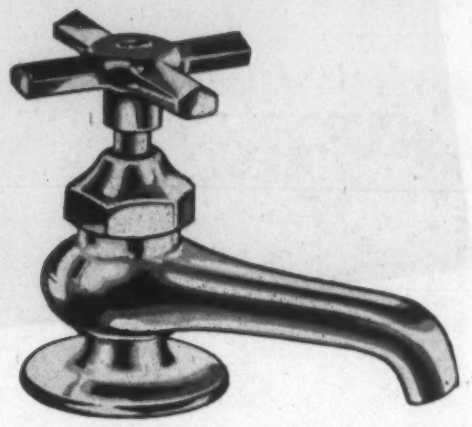
saves $170.35 per month in a single cleaning operation for Bohn Aluminum & Brass Corp.



THE Capitol Brass Works Division of Bohn Aluminum & Brass Corp. makes the kind of plumbers' brass goods that helps to bring chrome-plated beauty to modern kitchens and bathrooms. The metal cleaning operation prior to plating involves some special problems, one of which is the removal of the buffing compound used to polish the brass castings.

Too strong a metal cleaner could discolor the brass, yet ordinary cleaners were not effective. But one of the Pennsalt Cleaners was found to be completely effective, safe, and . . . exceedingly economical. By saving time and materials, it saves an average of $170.35 per month in the cost of a single metal cleaning operation.

This is but one example of what the Pennsalt Cleaners are doing for many industries. They have won their place in each plant by doing a better job at lower cost. For heavy-duty operations there is Orthosil, the original product in this line. For varied and extreme requirements there is a series of other Pennsalt Cleaners that meet every need with laboratory precision.

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CLEANERS FOR INDUSTRY

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Chemicals

In "City Gas for Special Atmospheres," C. R. CLINE & C. G. SEGELER (Am. Gas Assoc.) list the general types of controlled atmospheres as: partially burned gases, cracked hydrocarbon gases, cracked ammonia, nitrogen, CO_2-free partially burned gases, cracked methanol, charcoal producer gas, solid protective coatings, and vacuum. Purification methods are given as: condensation or washing, chemical purification, adsorption or absorption, and refrigeration.

A series of studies on the effect of burning fuel gas with insufficient air for complete combustion were reported. For a given fuel gas it was found that the composition of the product gas was chiefly dependent on the air-gas ratio, while at a given air-gas ratio the composition is primarily dependent on the total carbon and total hydrogen (either free or combined) content of the fuel gas.

Some New Atmospheres

The development of an atmosphere for protection of high carbon steels is discussed by J. R. GIER (Westinghouse Elec. & Mfg. Co.) in "Protective Atmospheres for Hardening Steel." This atmosphere is produced by the endothermic reaction of air and a hydrocarbon fuel in a generator containing an electrically heated catalyst. The product gas is said to be easily controllable, by varying the air-fuel ratio, to be in equilibrium with any medium- or high-carbon steel. This gas is produced in a single step and it is said that no drying or purification is required before use. The term "carbon pressure" is used in this paper to mean the carburizing potential of an atmosphere and is used to describe the results obtained with the new atmosphere.

Gaseous carburization is described by W. A. DARRAH (Continental Ind. Engrs.) in "Recent Development in Gas Carburizing —the Hypercarb Process." In this process unmixed city gas or straight natural gas is pre-treated at about 1700° F. before contacting the material to be carburized. Thermal circulation is preferable to forced circulation and is accomplished by introducing the carburizing gas near a hot radiant surface which causes the gas to rise as it becomes heated. The conditions for successful operation are: relatively slow and controlled circulation of the carburizing atmosphere, controlled pre-treating of the atmosphere, and prompt contact of the activated atmosphere with the steel being treated.

Various types of carbon cases may be produced by varying the point of addition of the carburizing gas and the temperature of operation. The refractory in the carburizing chamber must not contain appreciable amounts of iron oxide or carbon will precipitate thereon and cause disintegration of the refractory. However, iron in the form of a silicate is not troublesome.

Effects on Refractories

In "Effects Upon Furnace Refractories of Protective Gases for High Carbon Steels," JOHN H. LOUX (Salem Eng. Co.) reviews the literature and cites experimental results on refractory disintegration caused by controlled atmospheres. It has been found that protective gases for low-carbon steels did not cause disintegration of fire-brick but protective gases for high-carbon steels disintegrated these brick (although not affecting light refractory brick). This disintegration appeared in the temperature range 840°-930° F. and is probably caused by the deposition of carbon, according to the reaction $2CO = CO_2 + C$, which eventually bursts the brick.

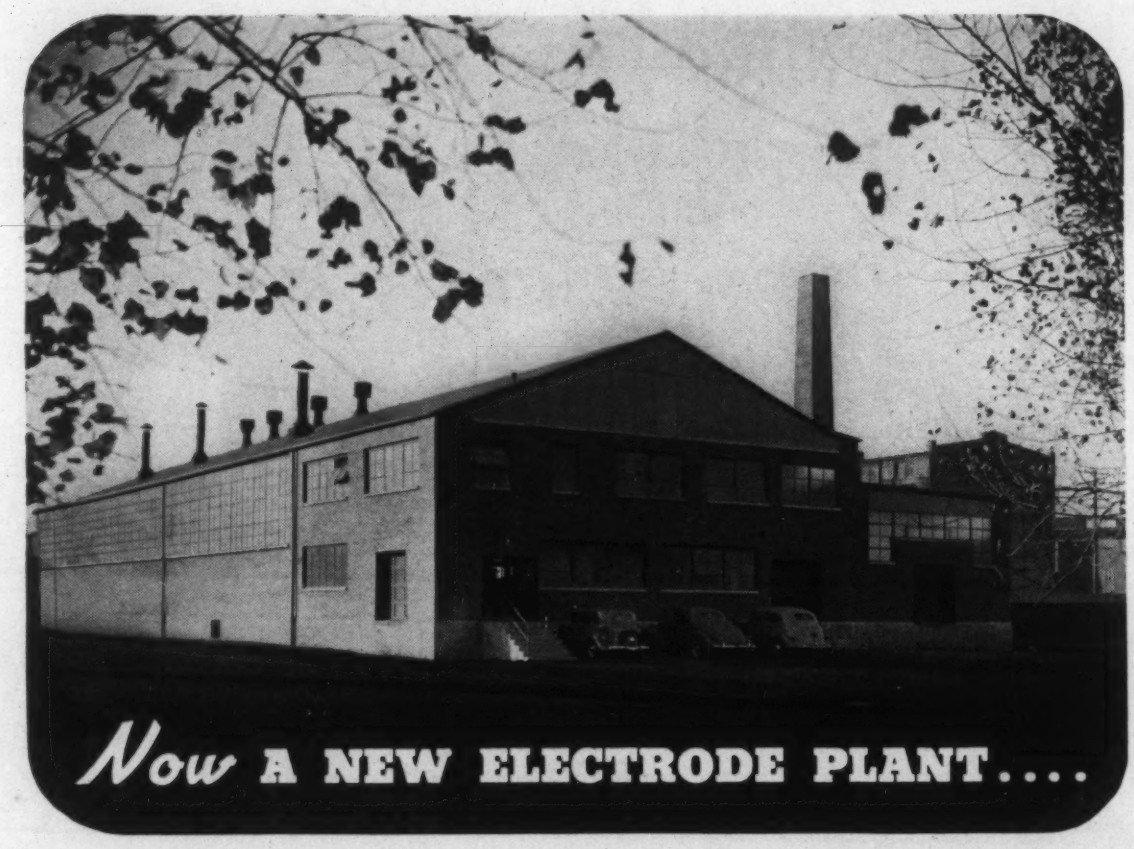
The deposition of this carbon within the brick is catalyzed by some material which previous work indicated was non-magnetic iron oxide (Fe_2O_3), probably in the presence of a small amount of iron. To prevent this firebrick disintegration a reducing firing of the refractory to convert the iron oxide to the magnetic form is only partially successful since, if the refractory subsequently encounters oxidizing conditions, the magnetic form will largely revert to the non-magnetic form.

A complete solution to the problem is to continue the reducing "burn" until both the iron oxide segregations and the metallic iron react with the silica in the clay to form an inert silicate glass. This latter treatment produces a firebrick which is said to be suitable for use with high-carbon steel protective atmospheres.

Tests for Decarb

Many pertinent practical data anent the whole subject of controlled atmospheres are contained in a 4-page article by N. K. KOEBEL of Lindberg Eng. Co. ("Industrial Controlled Atmospheres," *Iron Age*, Vol. 146, Nov. 21, 1940, pp. 33-39; Nov. 28, 1940, pp. 40-46; Dec. 5, 1940, pp. 45-51; Dec. 12, 1940, pp. 48-53). The methods used for testing for decarburization are of obvious importance, and include hardness tests, photomicrographic examination, analysis of consecutive cuts and determination of change-in-weight.

The hardness test is the most commonly used and the easiest to make; although it is the least accurate, it can be satisfactory if intelligently carried out with, say, the Rockwell superficial tester. Photomicrographs do not always give a true pic-



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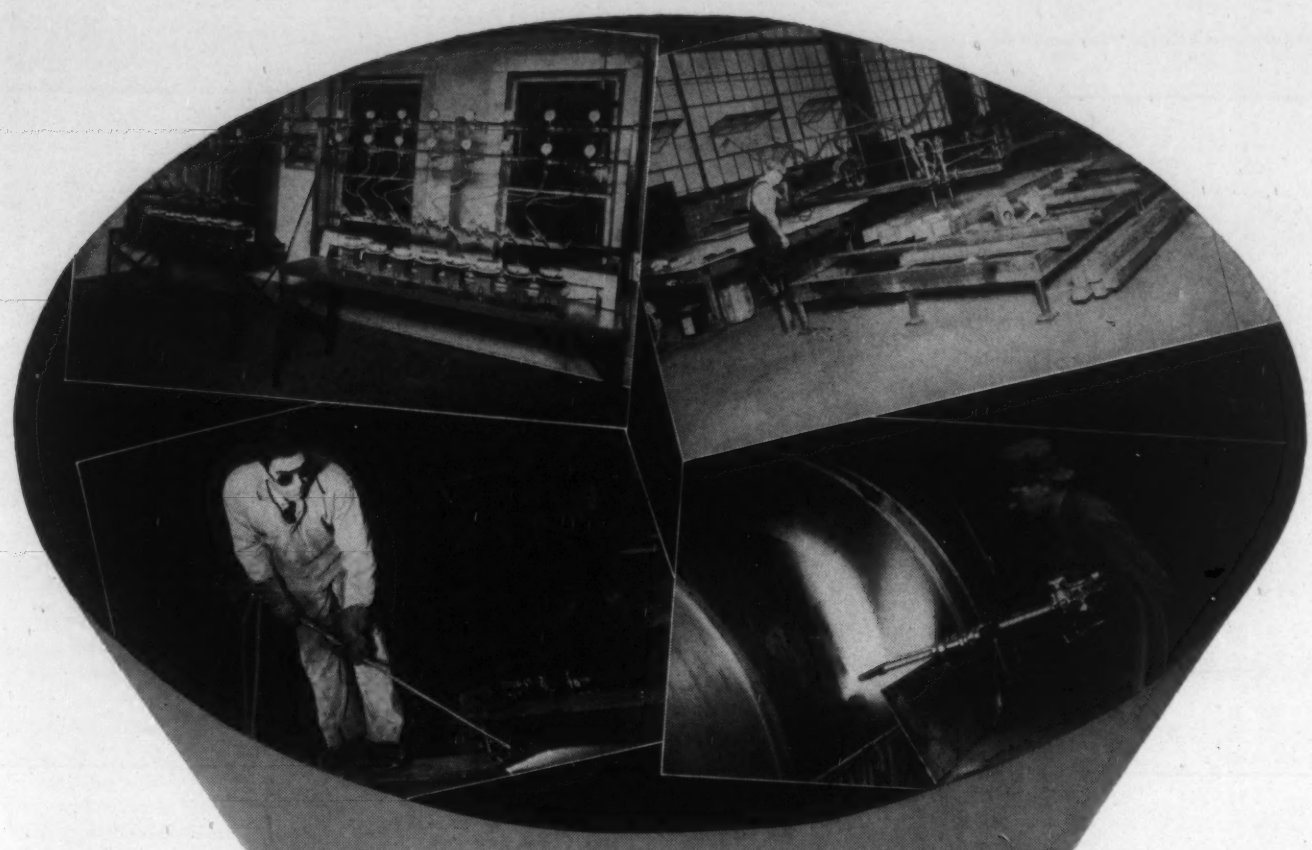

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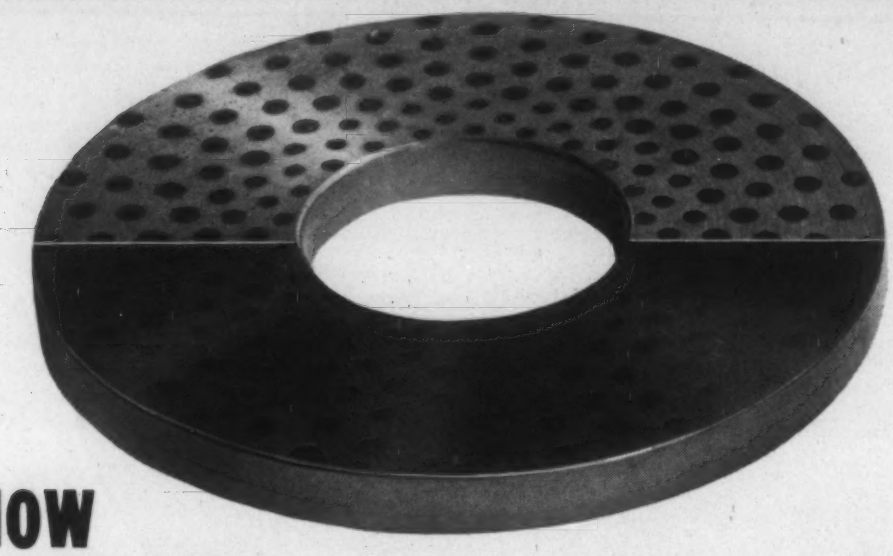

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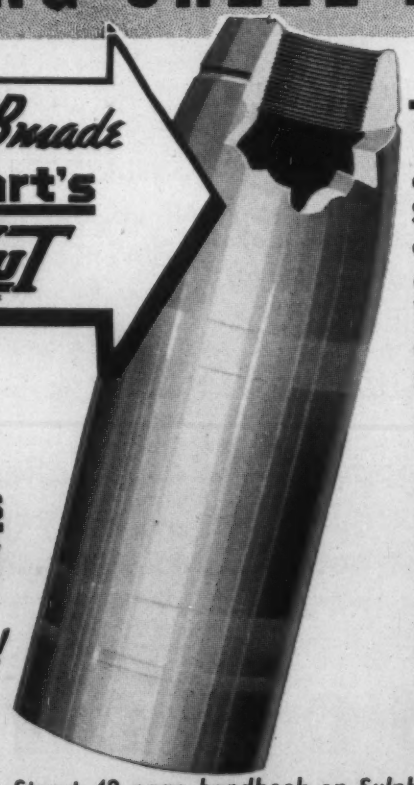

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ture of the total depth of decarburization; they cannot check small carbon loss or show the total depth of decarb. A complete picture is, however, given by taking consecutive cuts from a previously-analyzed and treated specimen and analyzing each set of turnings for carbon until the carbon content of the original piece is reached.

Also very accurate, and convenient and easy to make, is the "loss-in-weight" test, in which the steel sample is weighed in grams to the 4th decimal place, heat treated in the atmosphere under test, and reweighed. Any loss in weight is due to loss in carbon. Using a 5/8-1 in. diam. sample, 1 in. long, the theoretical allowable loss-in-weight limit for any steel may be set at 0.00020 gm./cm.^{2}, although the practical limit will depend on the thickness of piece and its carbon content.

Evaluation of Atmospheres

The most common basis for atmospheres is combustion of air and fuel gas mixtures, with control of product composition through air-gas ratio control. Such atmospheres can not be used for decarb-free heat treatment of high-carbon and tool steels unless slight scaling can be permitted. In any case there is usually only one air-gas ratio setting that can be applied, and this is useful only for a limited number of steels; a small excess (2-5%) of oxygen is essential. The most common mistake with air-gas ratio control is to use a setting that assures scale-free hardening; under such conditions decarburization will almost certainly occur.

"Reducing" atmospheres, high in carbon monoxide, are used with high speed steels, however, and the soft skin formed ground off before placing the tool in service. Such steels decarburize at temperatures as low as 1350° F., and therefore pre-heating atmospheres are also important. One non-decarburizing practice for high speed steels is to heat them with a "carbon block" in a silicon carbide muffle; the average life of the block at 2350° F. is 2-3 days' continuous use.

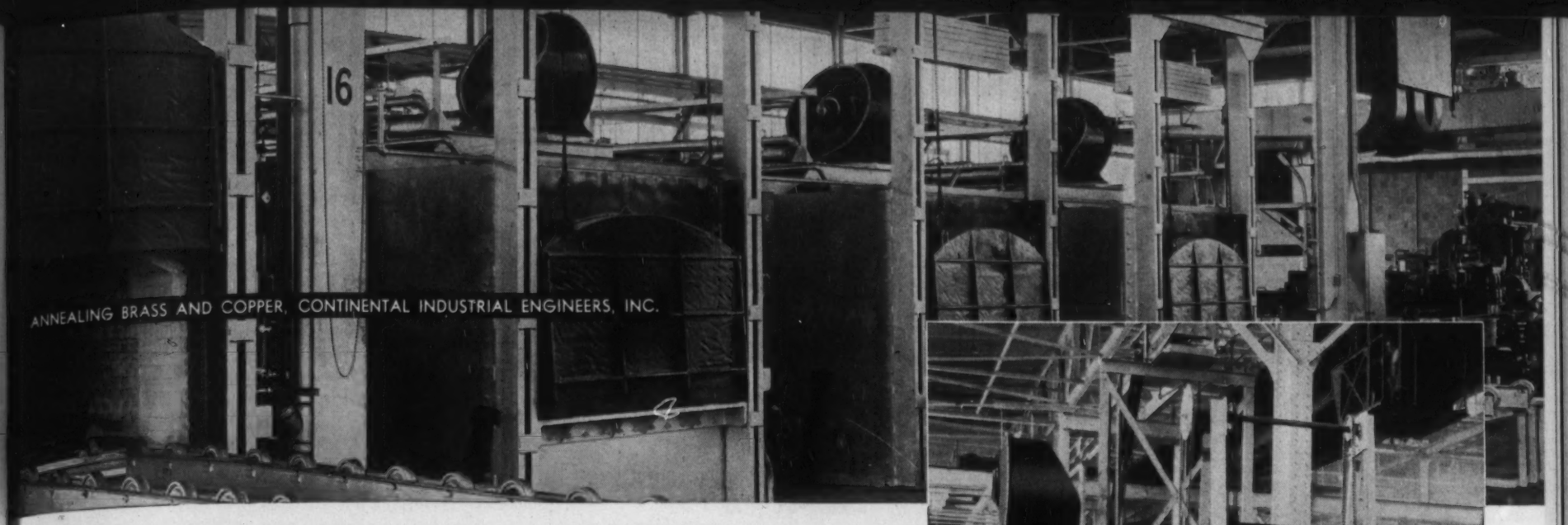
Carbon monoxide-nitrogen mixtures are ideal for heat treating any type of steel regardless of temperature or period of treatment, *provided the gas is free of carbon dioxide, hydrogen or water vapor.* Also, a highly-processed pure nitrogen is available, produced by an ingenious method involving perfect combustion and removal of carbon dioxide and water vapor. The initial cost of a nitrogen generator is $4000-$5500 for producing 300-500 ft.^{3} of nitrogen/hr.

To produce an inexpensive gas low in carbon dioxide, a method has been developed for double-cracking city, mixed or natural gas, and then carefully removing water vapor. One of the greatest contributions so far to the production of foolproof atmospheres has been charcoal generator gas and its combination with other gases.

Pure hydrogen or hydrogen-nitrogen atmospheres have been used very little for high-carbon and tool steels because they are too decarburizing, unless they are purified and *completely* dried, and kept dry in the furnace. With proper furnace design, as in one commercial furnace, a 75% hydrogen, 25% nitrogen mixture can be used for treating high-carbon, high-chromium tool steels without decarburization, carburization or scaling.

The trends in controlled atmospheres are stated to be toward the use of charcoal generator gas mixtures with other gases; and toward the cracking of anhydrous ammonia to give dry hydrogen-nitrogen mixtures, with the use of a special furnace for the mixture.

E. E. Slowter + VSP (2a)



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ANNEALING

Annealing is frequently the final touch at the point where the material becomes a finished product. All the investment in material and labor is at stake as well as the manufacturer's reputation with his customers.

The advance in the art of annealing has been marked by many improvements on the part of the furnace manufacturers, a few of which are illustrated on this page.

A smooth, continuous and reliable air supply under perfect control is a vital necessity. In all cases, perfect control of temperatures and a critical timing factor of both heating and cooling are involved.

These are some of the reasons why equipment manufacturers prefer Spencer Turbos.

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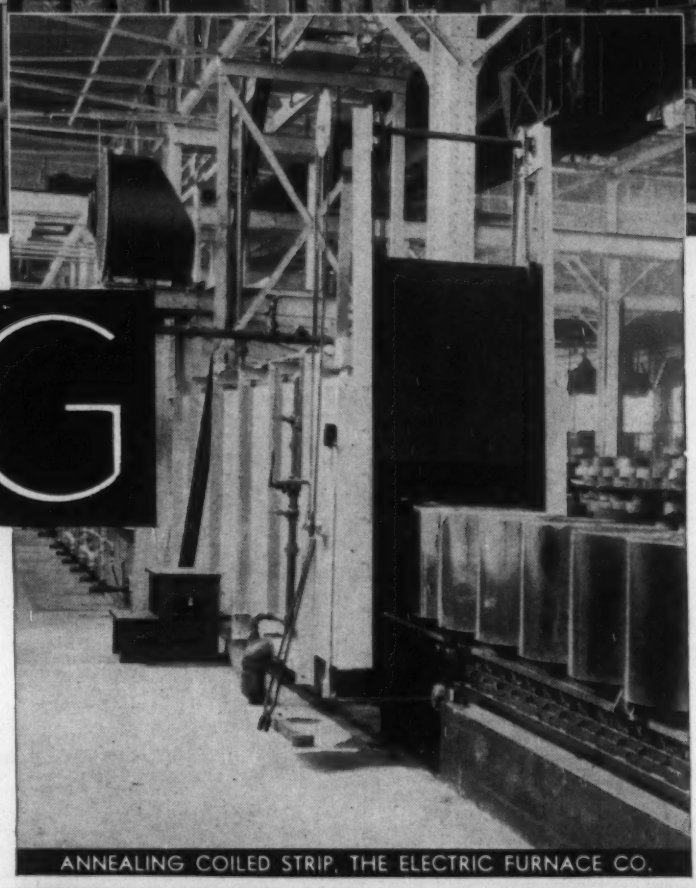

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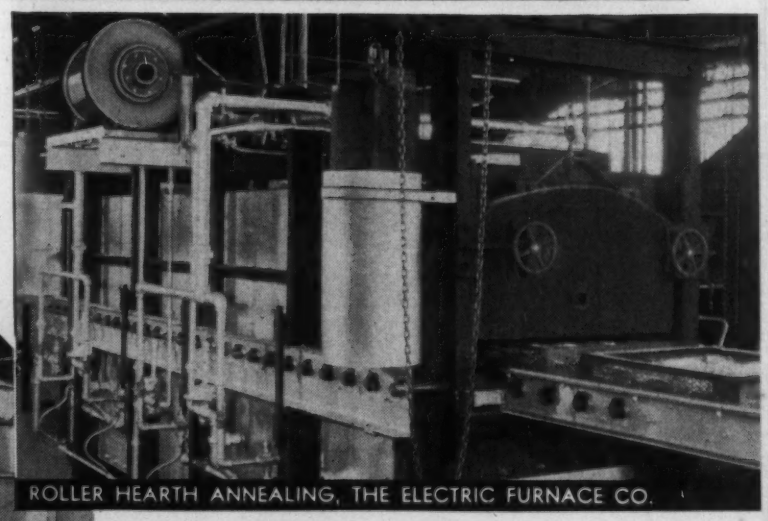

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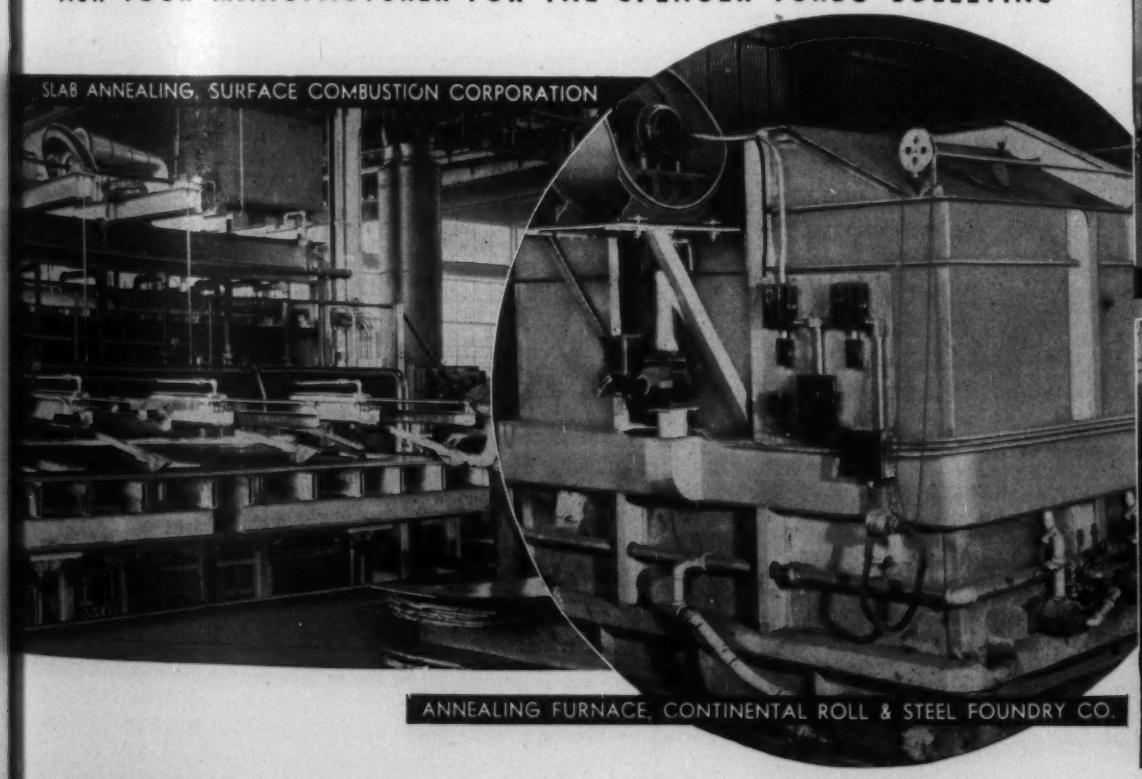

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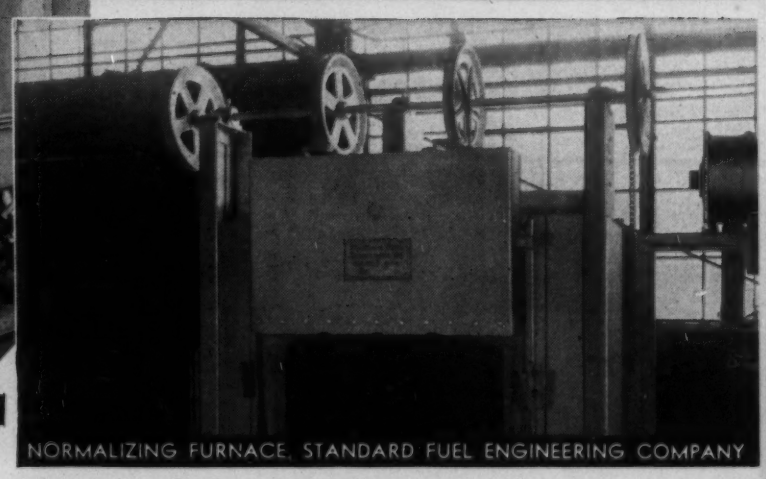

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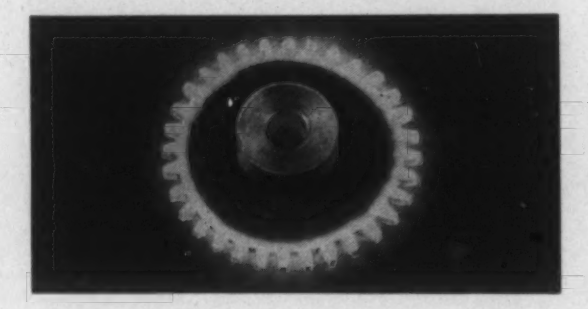

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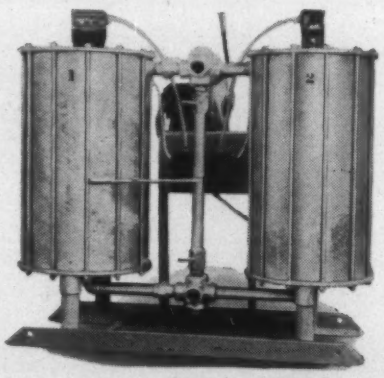

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Flame Hardening of Machine Parts

"The Production Flame Hardening of Machine Parts." John Erler & P. H. Tomlinson (Farrel-Birmingham Co., Inc.) *Welding J., N. Y.*, Vol. 19, Oct. 1940, pp. 705-709. Descriptive.

Flame hardening is used at Farrel-Birmingham for parts made from steel forgings, rolled stock, steel castings and Meehanite iron. The carbon ranges in the steels are 0.35 to 0.70% C, with manganese range held within close limits. For steel castings, the general specifications are for 0.55% C max. with 0.80% Mn max. Alloy steels are used only when special core properties are required for impact strength in service. Gray irons with 0.60% C (combined) min. are easily hardened, and Meehanite is considered to be the ideal cast iron.

Before flame hardening it is essential to relieve stresses by heating to above 1200° F. On castings no repair welds should be made on the surfaces to be flame-hardened because the weld produces a soft area and causes cracking where it joins the base metal.

Standards for setting up operating conditions for definite case depth and hardness for a given material are determined by hardening sections of a ring 17 in. O.D., 15 in. I.D. and 1 in. thick under varying conditions of speed of flame-travel, etc. The sections are broken and examined for case depth and hardness, and a curve is then plotted for case depth and hardness vs. speed, and the region of lower speed where grain growth occurs is mapped out. Four methods of reducing or eliminating distortion, used either singly or in combination, are employed.

The opinion is that if the quenching temperature ahead of the quenching jets could be determined, more accurate standardization would be possible. Some disadvantages of the flame hardening method are noted, such as a higher cost than for complete hardening of small parts, bad distortion of thin strip, danger of cracking where thin and thick sections meet, or over cored and drilled holes too close to the edge. Many advantages are listed and the varied applications are detailed in text and in photos. WB (2a)

Cold Trimming Drop Forgings

"Notes on Cold Trimming Drop Forgings." James R. Thain (General Metals Corp.) *Heat Treating & Forging*, Vol. 26, Nov. 1940, pp. 531-533. Practical.

Cold trimming is best for small lightweight forgings where there is danger of distortion if they are hot-trimmed. With high-carbon or alloy steels, normalizing or annealing usually precedes the cold trimming operation. Heat-resisting steels should be hot-trimmed and re-struck whenever possible. If such forgings must be cold-trimmed, they must always be annealed or normalized.

In trimming, the punch enters the metal for a considerable depth before fracture results. The depth of penetration for low-carbon steel may be as much as 50% of the flash thickness before failure occurs. Cold-working, however, decreases the depth of penetration and increases the shear resistance. If the low-carbon steel be cold-worked, the depth of penetration may drop to 37% of flash thickness and the shear resistance may increase from 35,000 to 44,000 lbs./in.^{2} Cold-working of the metal at the flash line will materially increase the power necessary to result in fracture. Cold-working at the trim

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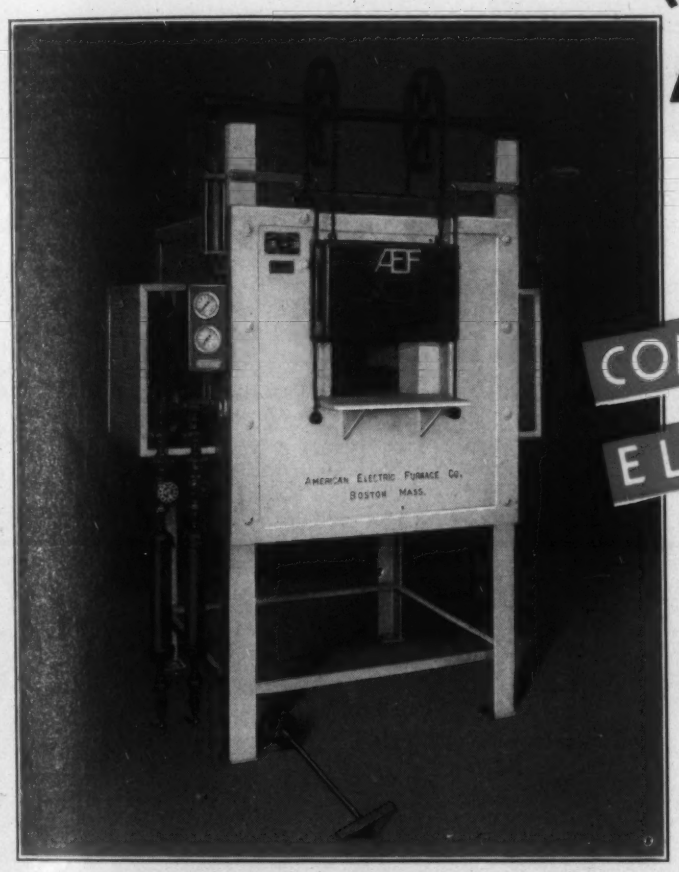

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line is usually due to poorly-fitted trimmers and punches.

With proper clearance between punch and blades, the forging will trim without any secondary shear marks and protruding flash, and with a minimum amount of press pressure. For mild steel forgings with 1/8-in. flash, steel having a 30% penetration and tools having a clearance of 10% of the flash thickness, the trimming pressure would be about 44,500 lbs./in.^{2} If the clearance be reduced to 3% of the flash thickness, the pressure will increase to about 47,000 lbs./in.^{2} Dull, rounded or chipped cutting-edges will increase the working pressure as much as 15%.

There is a difference of opinion regarding the correct amount of clearance. Some hold that the total clearance should be 10% of the flash thickness for mild steels, 12% for medium-carbon steels, and 5% for brass. Others assert that the clearance should be expressed in a relation proportionate to the ductility of metal as shown by reduction in area in a tensile test or percentage reduction in thickness before failure in shear. It is known that as clearance increases, the pressure falls, bending tendency increases, secondary shearing decreases, and spreading actions occurring during plastic deformation decrease.

In trimming austenitic steels at least twice as much power is required as for mild steels. Therefore, trimmer blades for these forgings must be sharp and closely adjusted, or the metal will bend over and work-harden before actual trimming begins. These forgings must have their flash almost completely penetrated; they do not break off. Shearing or grinding the face of the trimming dies at an angle reduces the amount of work required, depending on shear depth. With sheared trimming dies, the pressure builds up slowly and the final release becomes more gradual and without severe shock to press and tools.

In case of thin forgings having a large area, the shear must be in the dies so as to leave the trimmed section flat. Shear must be properly balanced so there will be no side thrust tending to make the die creep and reduce the clearance on one side or perhaps deflect the punch. Charts show required pressures to cold trim forgings of different materials and the effect of trimmer die shear on pressures required to trim 18-8 stainless and S.A.E. 1040 steels. MS (2a)

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Hydrogen and Weld-Cracking

"Defects in Weld Metal and Hydrogen in Steel." C. A. Zapffe & C. E. Sims (Battelle Memorial Inst.) *Welding J., N. Y.*, Vol. 19, Oct. 1940, pp. 377-395. **Research.**

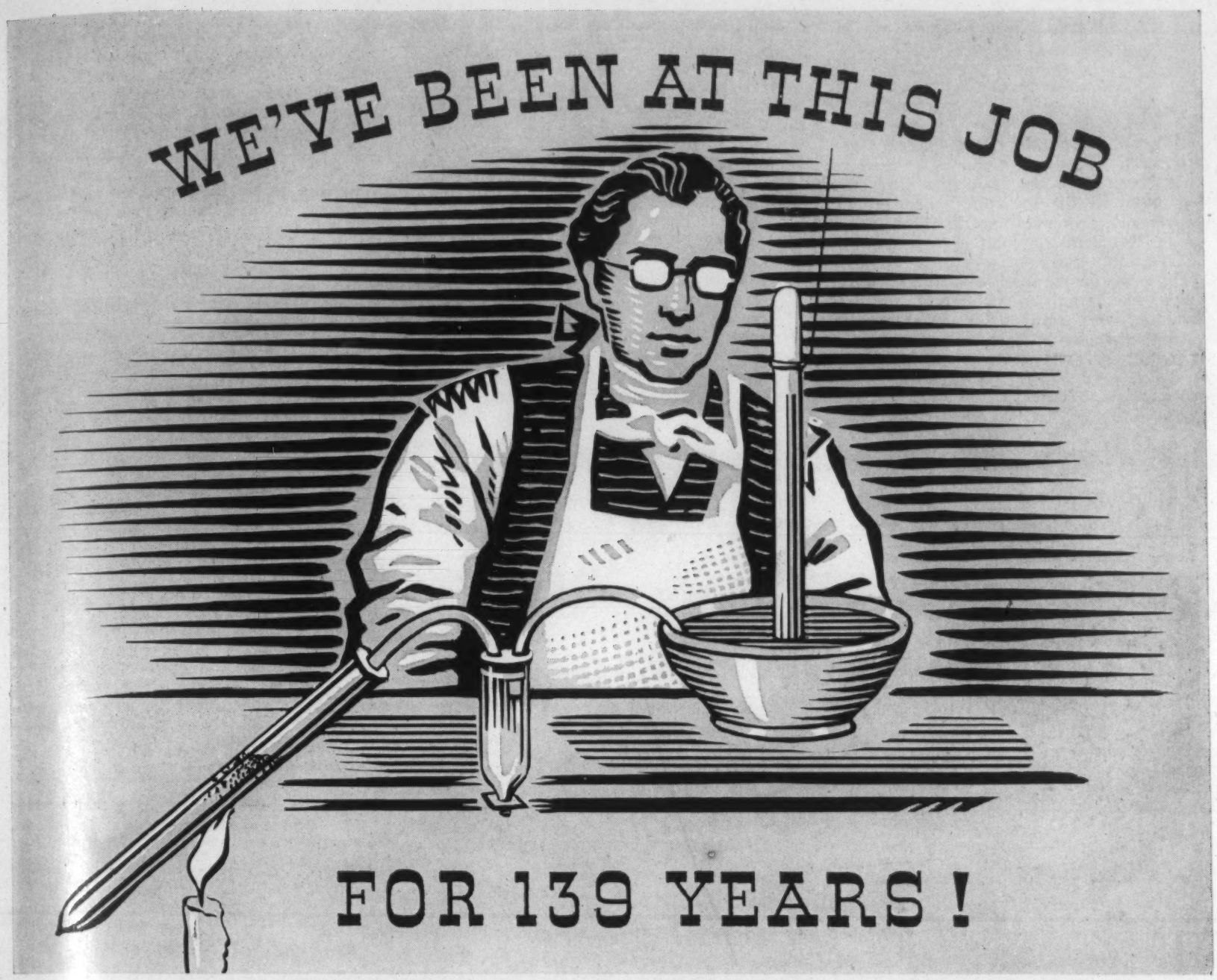
Hydrogen may cause cracking in welds just as it does flakes and fissuring in forged and rolled steels. The reaction of hydrogen with carbon in steel to form high methane (CH_4) pressures is postulated as a source of internal stress causing cracking.

The origin of hydrogen in welding may be from gases generated in the combustion of cellulosic portions of the electrode coating, and from decomposition of atmospheric moisture in the arc. The diffusion of atomic hydrogen and its collection at discontinuities and rifts causes high pressures of molecular hydrogen to exist. Relief of this stress comes through enlargement of the local storage space for hydrogen—the "fish eyes" familiar to all welders. The bright, silvery "fish eye" fracture surface was duplicated by the authors by cathodically loading steel samples with hydrogen and rupturing the specimens.

Peening of welds is regarded as beneficial in removing molecular hydrogen present in rifts and blowholes in welds, and the optimum temperatures for peening are considered to be between 200° and 750° F.

Data are presented on the effects of drying the electrode coating, of ordinary storage and of welding with the electrode surrounded by wet steam. The dried rod produced weld metal of the highest strength and ductility while the last 2 conditions gave approximately equal results. Another set of tests of welds made in dry weather and in rainy weather indicate that when the specimens were not permitted to age (by being kept at dry-ice temperature) the welds made in wet weather had somewhat lower strength and ductility; when aged for 2 weeks at room temperature, however, the reverse was found. Effusion of hydrogen from weld metal may take place slowly over a period of time at room temperature, thus increasing the ductility and strength.

Another series of tests surveys the effect of annealing temperature and time on the removal of hydrogen at temperatures of 225° to 1470° F., and times of 1/4 to 50 hrs. depending on the annealing temperature. Temperatures of 225° F. to about 1100° F. appear to remove hydrogen, as shown in values obtained for strength and ductility of weld metal. The optimum annealing temperature of 1110° F. for 15 min. is recommended with slow cooling to remove the hydrogen dissolved in the steel at the annealing temperature. WB (2a)



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Welded Pipe Fittings

"Investigation of Gas and Arc Fillet Welds in Piping." I. H. Carlson & E.R. Seabloom (Crane Co.) *Welding J., N. Y.*, Vol. 19, Nov. 1940, pp. 846-854. Investigation.

Previous codes for piping placed restrictions on fillet welded piping, which did not check with the properties that could be obtained for the joint when properly made. Part of the uncertainty associated with this type of joint was due to the adaptation of a massive screwed type fitting to use in the joint with thinner walled pipe. Redesign of the fitting for fillet welding has resulted in balancing the masses involved to give uniform heat distribution, assurance of penetration without burning, through the need for less weld metal and saving in time of operation.

Welds were made with the oxyacetylene torch using a single pass; arc welds were made in 2 passes. Smoother fillet welds could be made with the oxyacetylene torch, particularly on sizes of pipe below 1 in. The contour of the weld appears to be most critical in relation to the endurance limit of the fillet-welded pipe, and thus gas welds, because of their smoother contour, have a fatigue life double that of arc welds for the same stress. A 30° approach angle in the gas welds increased the fatigue life 20% over that for a 45° angle.

Both arc and gas welds in extra-strong grade "A" pipe lasted 17 times longer than screwed joints in the same pipe and 23 times longer than grade "B" pipe. In the bursting tests the gas-welded pipe usually broke well outside of the heat-affected zone, thus indicating the heat-affected zone as non-critical for the material tested. The conclusion is that fillet welds display excellent strength characteristics and can safely be employed in the same manner as butt welds, without any restrictions as to pressure and temperature.

WB (2a)

Aging to Improve Acetylene Welds

"Improving Ductility of Oxy-Acetylene Welds by Aging." J. R. Dawson & A. R. Lytle (Union Carbide & Carbon Res. Labs., Inc.) *Paper, Am. Welding Soc.*, Oct. 1940 meeting.

The ductility of oxyacetylene weld metal can be materially improved by treatment at lower temperatures than are ordinarily employed for annealing welds. Such "accelerated aging" treatments, especially at temperatures between 225° and 575° F. are of particular value in raising the elongation value of multilayer welds in plates of more than ⅝-in. thickness.

Oxyacetylene welds, when heated 24-72 hrs. at 225° F., or for 1 hr. at 575° F., are improved 30-50% in the value for percentage elongation, with corresponding improvement in reduction of area. This improvement is obtained both in single-pass and multi-pass welds. Welds in low alloy steels containing chromium, molybdenum, nickel, copper up to about 0.64%, and manganese up to about 1.36%, are improved in ductility. In the case of welds made with the chromium-containing rods the aging takes place in 1 hr. or less at temperature of 575° F. while a long period at 225° F. is required to give the same result.

The improvement in ductility appears to be even greater as a result of the low temperature treatments than is secured by the commonly used 1200° F. stress-relief treatment. The values for yield point and tensile strength in the tension tests and the results in hardness and impact tests were insignificantly affected by the treatments.

(2a)

Galvanizing Various Steels

"Galvanizing Characteristics of Different Types of Steel." Robert W. Sandelin (Atlantic Steel Co.) *Wire & Wire Products*, Vol. 15, Nov. 1940, pp. 655-676; Dec. 1940, pp. 721-749; Vol. 16, Jan. 1941, pp. 28-35. Unusually comprehensive investigation.

The lasting quality of a hot-dip galvanized coating is necessarily based on its thickness or weight, its tenacity or adherence to the steel base, and its appearance. But the ideal coating—a heavy adherent, bright, smooth, spangled layer—is not readily achieved, chiefly because of faulty galvanizing technique and incorrect choice of basis-steel composition. The effects of composition, revealed and correlated in this investigation, are shown to be positive and complicated.

A review of the literature indicates that most of the previous work, much of it contradictory, was concerned with the occurrence of the so-called "gray sheet." This undesirable finish has been variously attributed to hydrogen escape, porosity, over-oxidation of the steel, impurities in the zinc bath, slag inclusions, and formation of a complete alloy layer extending to the outer surface of the coating.

In the present work, 72 steels were prepared and studied, compositions being var-

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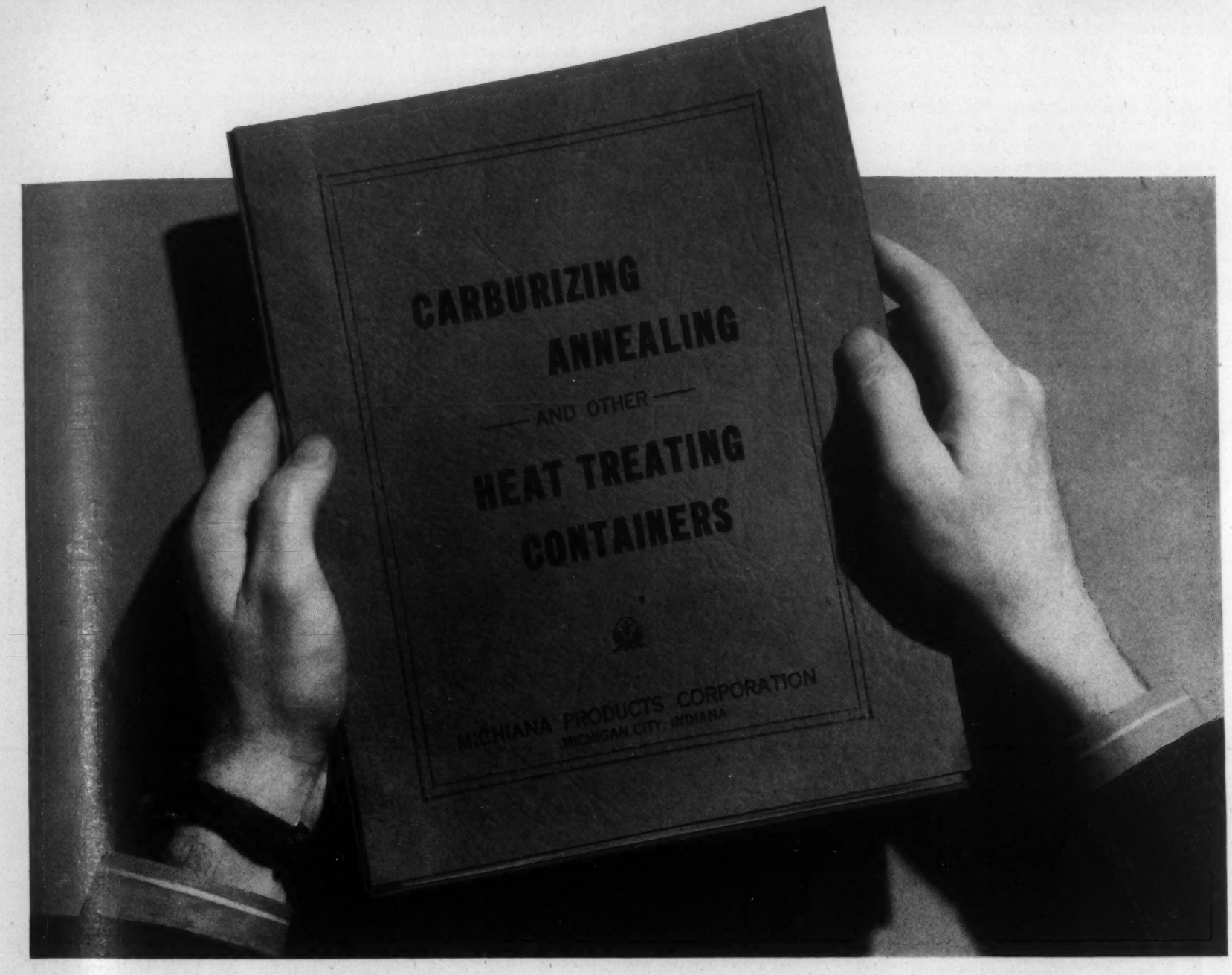

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ied through ferro-alloy or pure-metal additions to the ingot mold as each heat was poured. Square-section smooth samples were then cut from the rolled 1½-in. billet, ground to a high polish, and galvanized 72 at a time for controlled time periods after cleaning, pickling, fluxing, draining and drying.

The presence of phosphorus or silicon, or both, is most important in affecting the appearance of the coating. At short immersion times (30 sec.) fairly large amounts of these elements produce gray coatings. Longer immersion times may result in bright coatings, but the latter are most readily obtained by using low-silicon, low-phosphorus steel. Increased titanium and particularly aluminum tend to increase the brightening tendency at long immersions.

Silicon and phosphorus therefore affect also the coating adherence, since spangled coatings are more tenacious than "gray." Phosphorus contents lower than 0.040% P, however, are harmless, and even somewhat higher contents can be tolerated if high silicon also is present.

Coating weights also were most profoundly affected by silicon and phosphorus. Silicon has 2 effects, depending on the state of oxidation of the steel. In silicon-killed steels, extra silicon over the residual 0.10-0.15% Si tend to decrease coating weight; in low-silicon steels, the effect of initial additions of silicon is to increase the coating weight, although still higher silicon causes a dropping off.

In silicon-killed steels, increased phosphorus decreases coating weights; in low-silicon steels, phosphorus increases coating weights tremendously, particularly for long immersions. For a given silicon content, increased phosphorus decreases coating weight; for a given phosphorus content, the lowest coating weights are found in the range of 0.20-0.30% Si. Increase in aluminum content effected a marked decrease in coating weight, particularly after long immersions.

Microstructurally, increase in silicon content produced coatings consisting of iron-zinc alloys; the low-total-thickness range for silicon (0.20-0.30% Si) coincided with the maximum thickness of inner-alloy layer. In all the steels a marked increase in the thickness of the inner-alloy layer was always accompanied by a decrease in total-coating thickness and by a pronounced tendency for bright galvanizing at long immersion times.

Galvanizing tests made on wire and on bars drawn from commercial heats of steel indicated the effects of composition to be somewhat different than on the square-sectioned samples. Increased silicon aided very materially in improving coating adherence. By the use of steel containing over 0.15% Si the coatings could be water-quenched without ill effects, with consequent enhancement of brightness.

FPP (2a)

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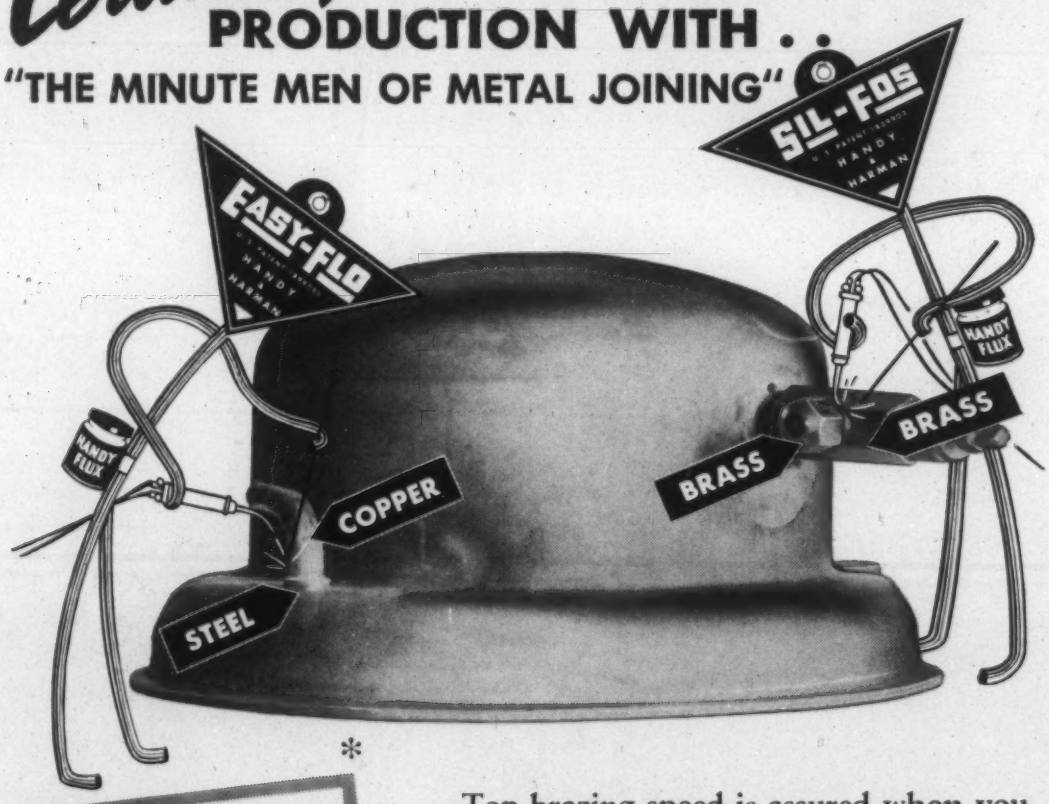

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Pickling Stainless Steel

"Pickling of Stainless Steel." Louis F. Loutrel, Jr. (Monsanto Chemical Co.) *Metal Finishing*, Vol. 38, Dec. 1940, pp. 645-646. Descriptive.

Mill scale and oxidation from annealing, soldering, welding, etc. on stainless steel present a difficult pickling problem, since the scale (oxides of chromium, iron and nickel) is tenacious and extremely resistant to acid attack. Ordinary acid mixtures strong enough to remove the scale usually attack the metal in the process, leaving it etched and rough.

Some success has been achieved with a mixture of 20% nitric acid of 38° Bé and 2% commercial hydrofluoric acid. The hydrofluoric acid is the active oxide solvent, while the nitric acid aided in this, but also passivates the underlying metal against attack by the hydrofluoric acid. However, the hydrofluoric acid is rapidly volatilized from this bath and control is difficult. Also, the fume hazard is great, and is accentuated by fumes of nitric oxide also given off.

Recent work has developed a new method of pickling 18/8 stainless that overcomes these disadvantages. The bath consists of ferric sulphate in conjunction with hydrofluoric acid; the ferric sulphate is a good passivator and in addition combines with hydrofluoric acid to form the non-volatile ferric fluoride, which aids in the scale removal. No fumes are evolved.

The exact amounts of ferric sulphate ("Ferrisul", 90% ferric sulphate, is used) and hydrofluoric acid in the pickling bath are varied according to the condition of the stainless steel and the type of scale. Hot rolled sheet is pickled for 10-20 min. in 8% Ferrisul, 2% HF; cold-rolled sheet for 5-15 min. in 6% Ferrisul, 1.5% HF; bars and wire for 10-40 min. in 6% Ferrisul, 2% HF; tubing for 20-60 min. in 10% Ferrisul, 3% HF; and cold-rolled strip for 1-4 min. in 12% Ferrisul, 2% HF—all at 160°-180° F.

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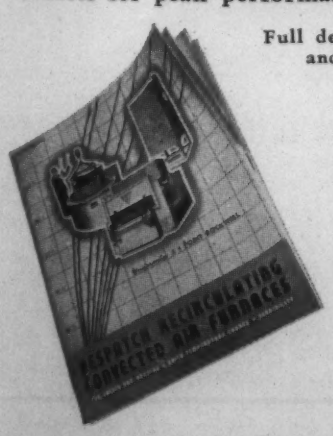

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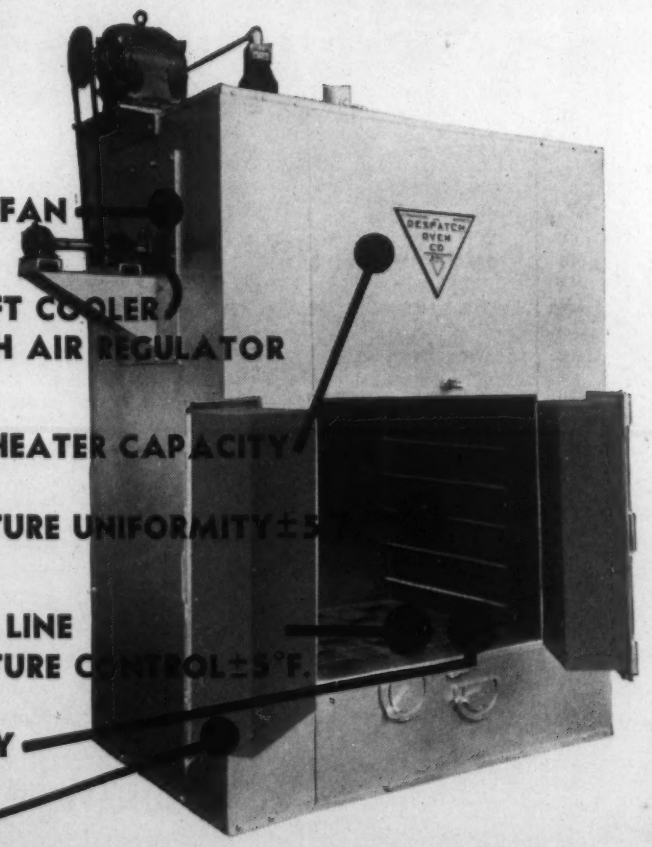

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savings in metal; the ferric sulphate-hydrofluoric acid baths remove between 1 and 3 lbs. of *metal* per ton after scale removal, as compared with 5-15 lbs./ton by other methods. FPP (2a)

Furnace-Brazing Carbide Tools

"Brazing Carbide Tools." Wm. S. Morse (Morse Tool Co.) *Ind. Gas*, Vol. 20, Jan. 1941, p. 11. Practical.

Cementing of carbide tips to tool shanks has been a generally retarding factor with respect to mass production. Not only must a perfectly clean surface be obtained for brazing, but shank decarburization must be avoided; before controlled atmospheres were available, tedious hand-fluxing of the entire tool followed by careful grinding-off of flux and excess brazing alloy were necessary.

The author's company is now using for this purpose a semi-continuous Surface Combustion gas-fired furnace employing an atmosphere ("Char-Mo") of nitrogen and carbon monoxide produced from charcoal in a self-contained generator. The furnace has 3 zones—one for pre-heat, a second for brazing, and a third for cooling—with the protective atmosphere introduced into all three.

Tools are placed on open trays and manually pushed through the furnace, which brazes 2,000 pieces per 16 hrs. The cycle is 1½ hrs.—15 min. preheat, 5 min. brazing and 70 min. cooling. The direct production cost of the atmosphere on this basis is $1.12/1,000 pieces—the cost of the 50 lbs. of charcoal used in 16 hrs. FPP (2a)

2b. Non-Ferrous

Welding Copper Sheet

"Welding Sheet Copper." A. J. T. Eyles. *Sheet Metal Inds.*, Vol. 14 Oct., 1940, pp. 1109-1110. Practical.

Oxy-acetylene welded joints in copper are claimed to be far superior to brazed or riveted joints. Precautions must be taken that the molten copper does not absorb oxygen, hydrogen and other gases, as the joint would then be weak. The usual practice is to incorporate deoxidizers in the welding rod and to use deoxidized copper sheet. It is well to specify copper completely deoxidized with silicon, and with a residue of 0.05-0.15% Si to compensate for loss of the latter in welding.

The metal near the proposed joint should be as clean as possible before the welding is started. Allowance should be made for the large expansion of copper on heating; the exact amount depends on the size of sheet, the speed of welding, etc. Good welds are obtained only if the blowpipe constantly maintains a neutral flame, which prevents oxidation and decreases the absorption of gas.

Pre-heating is necessary only when welding large sections, to save gas and the time of actual welding. The welded joint naturally has the strength only of cast copper, but this can be increased by cold hammering over the area of the weld. Annealing is desirable after hammering as it not only improves the ductility and workability but acts also as a stress relieving treatment (usual temperature, 1200°F.). JZB (2b)

Welding Nickel Alloys

"Welding Nickel and Its Alloys. A Review of the Literature to Jan. 1,. 1940." W. Spraragen & G. E. Claussen. *Welding J., N. Y.*, Vol. 19, Nov. 1940, pp. 441s-464s. Review of welding, brazing and soldering methods, with 237 references.

For wrought nickel the welding procedures are nearly the same as for Monel and are not radically different from those for mild steel. Sheet as thin as 0.016 in. and as thick as 3/16 in. has been oxy-acetylene welded. A slightly reducing flame is preferred with tip one size larger than for steel in order to provide a soft, low-velocity flame with minimum agitation of weld puddle. No flux is used, hence the weld puddle is more sluggish than for Monel where a flux is used. The welding quality of nickel filler rods has been improved by additions of manganese, magnesium, lithium and titanium.

Good arc butt welds (lower limit 0.037 in. thick), are made with heavily-coated electrodes, in which the core rod contains ¾% Ti and some magnesium to reduce porosity. Other successful welding methods are atomic hydrogen, spot, seam, resistance, butt and flash welding. For repairing nickel casting defects, a preheat of 1200° F. and a 75-90° Vee is required for oxyacetylene welding; arc welding requires no preheat but must be stress-relieved. Good silver-brazed joints are made with alloys containing 50% Ag, 18 Cd, 16.5 Zn, 15.5 Cu and 50% Ag, 34 Cu, 16 Zn.

For Monel, the procedures are much the same as for nickel except for such details as the use of flux with Monel (equal parts of borax and boric acid to form a

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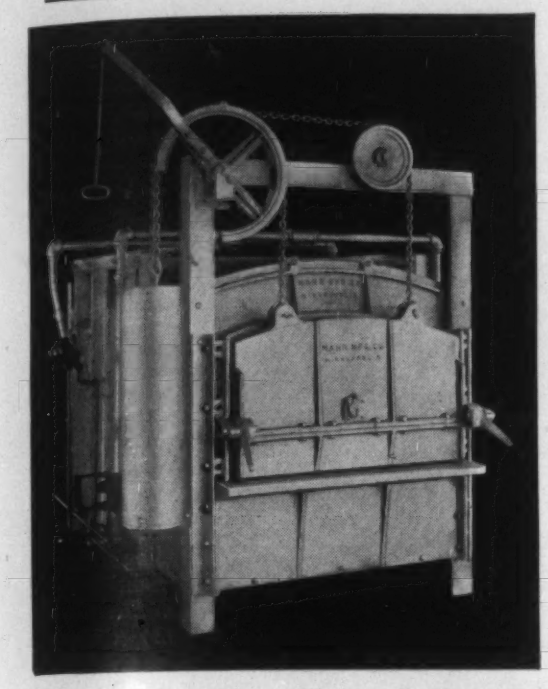

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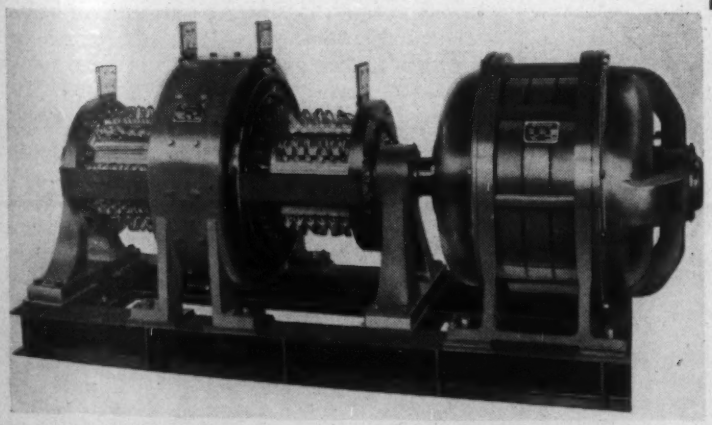

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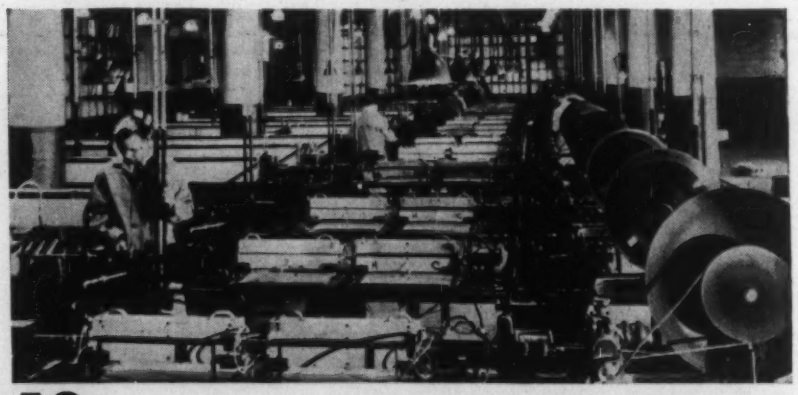

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saturated solution in alcohol); a special filler rod containing silicon has been used without flux and with a neutral flame for welding acid-service equipment. For arc welding, reversed polarity and heavily coated electrodes, the core rods of which contain 2% Al to deoxidize the weld puddle and eliminate porosity, are used.

WB (2b)

Bright Plating and Alloy Plating

A Composite

Two plating developments that have been increasingly applied in recent years and whose future seems "bright" indeed are the commercial production of bright electroplates and the preparation of alloy coatings. The two are to some degree related, since many of the bright nickel baths really produce "alloy" plates. Separately, bright plating offers great possibilities for the metallurgical design or process engineer in providing lustrous electroplated metals without the extra cost and trouble of buffing, and the use of alloy plating allows flexibility in the choice of decorative electroplates, gives better corrosion protection than single metals in some cases and provides new types of engineering materials, particularly alloy-plated bearings.

Bright Plating

A general description of modern bright plating methods is given by Jos. B. KUSHNER ("Modern Bright Plating," *Metal Progress,* Vol. 38, Dec. 1940, pp. 781-783). There are 5 or 6 commercial methods in use today, falling into 2 general classes: (a) processes using organic addition agents solely, and (b) processes that use other metals as well as organic agents.

The outstanding example of bright plating is nickel, and practice with this metal serves excellently for general illustration. The organic compounds used are generally sulphonated napthols. An exception to this is the process involving the co-deposition of cobalt in the presence of formates and formaldehyde. Almost all bright plating baths contain surface tension depressants, which help reduce pitting to a minimum by preventing the adherence of gas bubbles and foreign matter to the cathode surface.

For nickel, the basic solution used is the hot (85°-165° F.) Watts type bath, usually operated between pH of 2 and 4.5 at relatively high current densities (20-120 amps./ft.^{2}). The baths contain 20-40 oz./gal. nickel sulphate, 4-8 oz. nickel chloride, 4-6 oz. boric acid, and brightening agents as required. According to C. B. F. YOUNG ("Studies in Bright Nickel Plating Processes," *Proc. Am. Electroplaters' Soc.,* 1940, pp. 124-132) the customary napthalene trisulphonic acids, sulphonated oleo resin, benzene or p-toluene sulphonamide used as brighteners may be supplemented with zinc or cadmium salts for further improvement.

"Alloy" Bright Plating

Among a host of other things, the large field of bright plating with "alloy" baths is reviewed by C. L. FAUST ("Electrodeposition of Alloys, 1930 to 1940," *Trans. Electrochem. Soc.,* Vol. 78, 1940; Preprint No. 7, 34 pp.) in an evidently complete review of the periodical and patent literature on alloy plating in the last 10 yrs. The bright "alloy" nickel plating processes of greatest present commercial importance involve (1) the deposition of nickel-zinc (up to 4% Zn) alloy from sulphate baths containing zinc and an aryl sulphonic acid as brighteners, and (2) nickel-cobalt alloy deposition (bright plates containing from 1 to 40% Co are being produced) from Watts type baths containing formate, formaldehyde and ammonium salts.

Nickel-cobalt alloy deposition is flexible and suitable for heavy production schedules. Expansion in its application has been extremely rapid; in 1938 the annual consumption of nickel-cobalt anodes reached 100,000 lbs.

According to LOUIS WEISBERG ("Recent History of Certain Cobalt-Nickel Alloy Plating Solutions," *Trans. Electrochem. Soc.,* Vol. 77, 1940; Preprint No. 18, 7 pp.), a deposit containing 5% Co is practically as bright as one containing 18% Co, and a deposit containing 1% Co is semi-bright and can readily be buffed to a high finish. The 1% Co deposits are produced from baths with 0.4 oz./gal. cobalt sulphate and the 18% deposits from electrolytes with 1.6-2 oz./gal. cobalt sulphate.

The composition of one recommended bath is thus 32 oz./gal. nickel sulphate, 4-6 oz./gal. nickel chloride, 6 oz./gal. nickel formate, 4 oz./gal. boric acid, 1.6-2 oz./gal. cobalt sulphate and 0.15-0.35 oz./gal. ammonium sulphate, and 0.15 oz./gal. formaldehyde. The pH is 2-4, and the temperature 140°-160° F. As the amount of impurities is reduced, the amount of cobalt needed for a bright deposit can also be reduced, hence it is desirable to remove organic contaminants and metal impurities by treatment with

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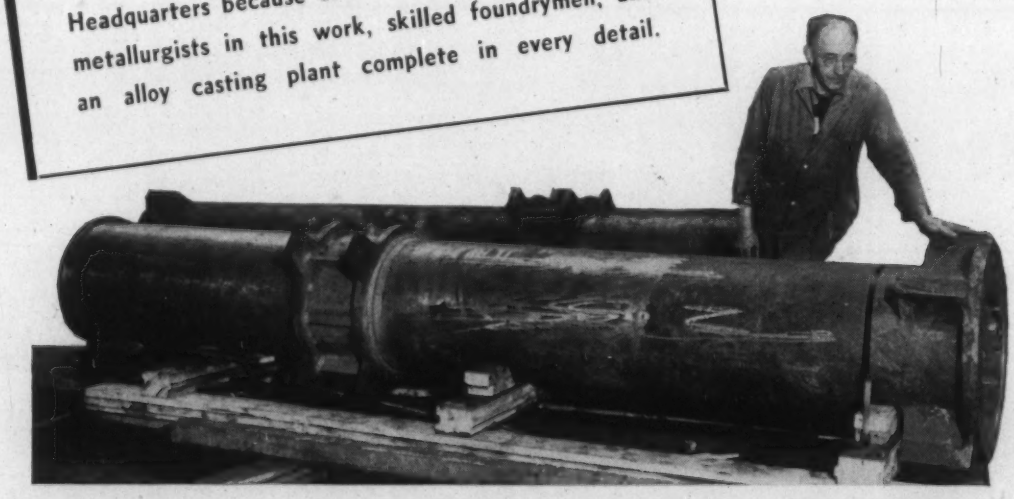

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activated carbon and clay, and by low-current-density pre-electrolysis.

Bright tin deposition is cited by Faust as possible from sodium stannate baths containing sodium acetate and free alkali, with additions of copper, nickel or silver cyanide. The deposit has a melting point of 500° F. or less and contains 2-15% Cu or 0.5-2% Ni. Heating after co-deposition is essential to brightness.

Bright zinc plating processes, all from cyanide baths, employ iron, cobalt, molybdenum or nickel as the co-depositing metal. Bright cadmium may be deposited from cyanide baths containing a small amount of silver or tin. One process electrodeposits hard, bright zinc-rich cadmium-zinc alloys from cyanide-caustic baths at 20-40 amps./ft.^{2} on iron and steel, and the deposits are more adherent than cadmium or zinc alone.

Industrial Uses of Alloy Plating

Faust reviews the general engineering applications of alloy plating in addition to the "bright-plating" field. Brass plating is used to ensure the adhesion of rubber to steel; the fast-curing commercial rubber stocks will adhere to alpha brass but not to other metals and alloys, and most of the larger rubber companies are plating brass on steel for this bonding purpose. A similar application is the strike-plating of silver-copper alloy on steel cutlery before plating it with silver.

Alloy deposition should also find application where a relatively expensive metal can be co-deposited with a cheaper one to give a deposit with the essential properties of the former. "Cold casting" of alloys has possibilities, also; one company electrodeposits a nickel-iron alloy (5% Ni), to build up small or worn parts, from acid sulphate baths containing fluorides.

The electrodeposition of bearing alloys is a highly promising field. It has been reported that cast silver has excellent bearing properties, and that electrodeposited silver is even better. This relationship between cast and electrodeposited metal may pertain to other bearing alloys as well.

Pilot plant operations have demonstrated the feasibility of producing heavy duty electrodeposited cadmium-silver alloy bearing surfaces with composition control in production work. Plates up to 0.030 in. of cadmium-rich alloys were plated at a rate of 0.0015-0.003 in./hr. from cyanide baths. Bearing test machine results showed that electroplated cadmium-silver bearing liners functioned suitably at heavier loads and higher temperatures than babbitt.

As already described in feature articles by Dayton in METALS AND ALLOYS ("The Possibilities of Silver-Rich Alloys as Bearing Materials," Dec. 1938, p. 323; "Low Lead-Silver Alloys for Bearings," Oct. 1939, p. 306), silver-lead bearings have given very good performance under relatively heavy loads, and electrodeposition of the alloy (96% Ag, 4 Pb) gives an excellent bond with the steel backing. The bearings are highly resistant to seizure and have the necessary physical properties to enable them to carry high loads without mechanical failure. Silver alloy bearings are particularly applicable for heavy-duty aircraft engines.

Although not exactly "alioy plating," the production of an alloy by plating a layer of one metal on another and then heat treating to cause alloying through diffusion should be mentioned. In the bearings field one of the most promising of such developments is the production of cadmium-silver-indium alloy bearing surfaces by electroplating indium on cadmium-silver bearings and then diffusing the indium into the surface through heat treatment. First described by C. F. Smart (METALS AND ALLOYS, Vol. 9, Sept. 1938, p. 569 L 5). Such bearings are well bonded to the steel back and provide increased resistance to corrosion by oils under severe operating conditions. X (2b)

Forming Aluminum Aircraft Sheet

"FORMING PRACTICE FOR HIGH STRENGTH ALUMINIUM ALLOY SHEET." J. V. L. *Sheet Metal Inds.*, Vol. 14, Oct. 1940, pp. 1085-1088. Practical.

Aluminum-coated DTD 390 (4.2% Cu, 1.2% Mg, 0.7% Mn; equivalent to Alcoa 24S) is supplied in the fully heat-treated condition for aircraft skin coverings and other components requiring only simple forming. However, when severe forming such as deep-drawing is involved, the sheet must be in the annealed condition.

Although the general recommendation is to anneal between the successive stages of cold working (usually the sheet is heated in a forced-air-circulation furnace to between 650° and 800°F. and allowed to cool slowly), some manufacturers have preferred solution heat treatment in a salt bath, because of the decreased time necessary and because 2 furnaces, one at the annealing and one at the solution temperature, are not required. Salt baths are not satisfactory for annealing because the nitrate adheres to the sheet during the slow cooling, while the quench in the solution treatment effectively removes the salt. The number of heat treatments permissible is bound up with the question of grain growth

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and of decreased corrosion resistance as a result of diffusion of the aluminum coating.

Tool design must allow for the lesser spring-back in forming, as compared with steel, due to the low modulus of elasticity of aluminum. Aluminum has a high coefficient of surface friction, so best results are obtained with polished dies. A lubricant is necessary in all forming operations, but the soft pure aluminum coating functions to a certain extent as a lubricant and appreciably assists in the forming and also in preventing cracks during bending.

The clearance between the punch and die should be about ¼ the thickness of the sheet. In a pressing where the whole area is cold-worked, then ¼-½ hard sheet should be used to ensure sufficient strength in those parts which are not work-hardened.

Safe bend radii officially (Great Britain) set up for aircraft are given in the Table.

Minimum Bend Radii

Thickness	<18 S.W.G.		>18 S.W.G.	
Angle of bend	<120°	>120°	<120°	>120°
Annealed	½T	1T	½T	1T
Solution treatment	½T	1½T	1½T	2T
Heat treated	2T	3T	2½T	3T

T = thickness.

These radii apply to the forming tools; the radii on the finished article are slightly larger due to spring. The sheet should be constrained to follow the profile of the tool to prevent sharper radius bends than required. Designers should be careful not to specify sharper bends than required.

JZB (2b)

Machining Brass and Bronze

"The Machining of Brass and Bronze Alloys." W. M. Ball, Jr. (Edna Brass Mfg. Co.) *Modern Machine Shop*, Vol. 13, Dec. 1940, pp. 72-74, 76, 78, 80, 82, 84, 86, 88. Practical.

The first important item in the machining of brass and bronze is the machine tool. Not only should it be rigidly set and properly insulated from vibration, but power, feed and speed must be carefully selected. Too slow speed, for example, is a common cause of poorly-machined surfaces on brass castings.

Carbon steels, high speed steel and sintered carbide tools all have logical applications in the machining of copper alloys. On rough jobs or on castings with sand in the surface, sintered carbides will do the best job.

For turning copper a tool should be used that has a built-up edge, extreme cutting rake and plenty of clearance; by taking light cuts at high speeds, coolants or lubricants may be dispensed with. Hard (low-alloy) coppers are best machined with tools with very little rake and coolants.

High-tin bronzes should be machined with tools having no rake at all and ground similarly to tools for cast iron. No coolant or lubricant is required. The brasses are generally machinable at very high speeds and feeds without the aid of coolants or lubricants. Tools are of normal design with only slight rakes and clearances.

Leaded bronzes offer some difficulty because of the tendency of the tool to cut into the soft lead and then ride high over the harder bronze matrix, producing a rough surface. Tools should have a very keen edge, and high speeds with light cuts are essential to the best finish. The rake can be zero or slightly negative.

The presence of appreciable nickel in a bronze makes mandatory the use of coolants. Also, the tendency to gall that nickel may introduce requires the tools to be ground with positive rake and clearance. Nickel brasses, however, may be machined very easily at high speeds, using tools cut to a straight angle; more power will be required because of the higher tensile strength of the nickel alloys.

In machining very high-strength aluminum-bronzes, coolants should be used, and the tool should be ground so that it just *scrapes* (rather than cuts) the metal. Less strong aluminum bronzes (about 70,000 lbs./in.^{2}) are, however, *cut,* using lipped tools with plenty of clearance and lubrication.

In any case, a knowledge of the composition and of the effective machining characteristics of individual alloying elements is essential. Zinc aids machining whereas nickel and aluminum complicate matters. Hardness alone is no criterion of machinability, since two alloys of the same "hardness," one a leaded bronze and the other an 88-10-2 copper-tin-zinc alloy, will have entirely different machining characteristics. (2b)

Tin Plating from Stannate Baths

"Study of Sodium Stannate Tin Plating Solution." Frederick Bauch (Frigidaire Corp.) *Proc. Am. Electroplaters' Soc.*, 1940, pp. 113-119. Research.

The sodium stannate bath gives smooth, compact deposits over a fairly wide range of conditions, but some care is required for continuous operation. At a low anodic current density, tin dissolves as stannite, which causes porous deposits. If the anodic current density is raised above a certain critical value, the tin dissolved as stannate. The current density can then be lowered somewhat, and the tin will still dissolve as Sn^{IV}. Interruption of the current will cause the anode to dissolve again as Sn^{II}.

The anodic behavior is erratic if the free sodium hydroxide concentration is less than 1 oz./gal. Stannite in a bath may be removed by oxidation with hydrogen peroxide or by electrochemical oxidation, using insoluble anodes. Because of the changing load in a plating bath, it is difficult to control closely the anodic current density. The anodic current efficiency decreases as the current density is raised.

The cathodic current efficiency is nearly 100% under favorable conditions but decreases rapidly as the free sodium hydroxide content of the bath is increased above 1 oz./gal., and as the current density is increased above 20 amps./ft.^{2} A high metal content, a high temperature (180°F.), and the presence of sodium acetate favor a high cathodic current efficiency. The throwing power of the bath is improved by an increase in the concentration of the following: free sodium hydroxide, sodium stannate, sodium carbonate and sodium acetate.

AB (2b)

Indium's Price—A Correction

In a digest on "Indium Plating" on p. 88 of our January issue, the statement was made that "the price of indium is still high—$240 per oz." This figure was the one given in the original paper from which our digest was prepared.

Actually, the price of indium is now surprisingly low. According to the Indium Corporation of America, New York, the price of electrolytic indium, 99.99% pure, is $30.00 per troy oz.; of commercial indium $12.50 per troy oz.; of indium oxide, $14.75 per troy oz.; and of indium sulphate or chloride $7.00 per troy oz.

The high figure transcribed by us gives an utterly false picture of the real commercial applicability, on a cost basis, of this interesting and potentially highly useful metal.

—F.P.P.

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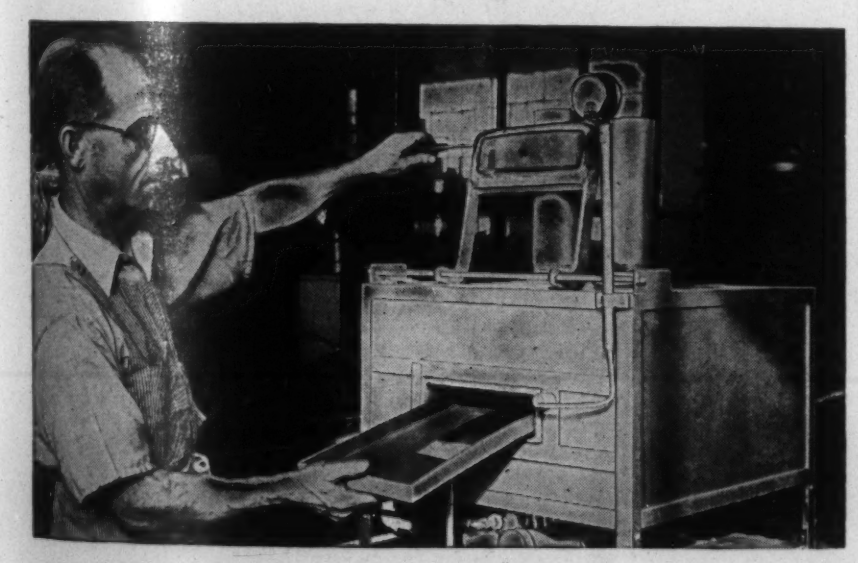

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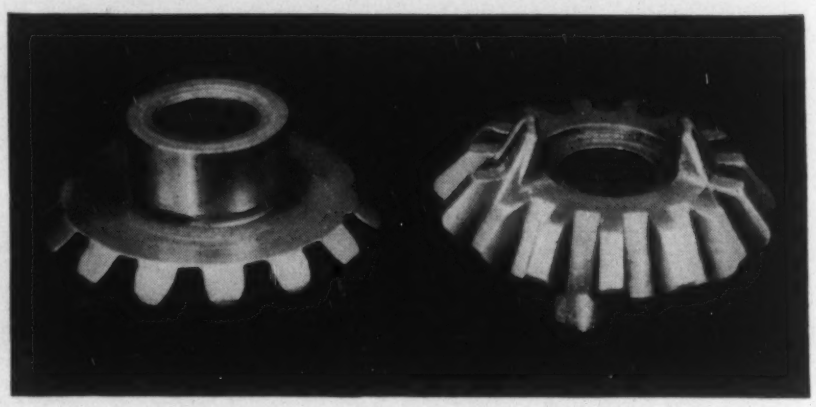

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METALS, ALLOYS, METAL FORMS
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Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Metallurgical Design of '41 Cars

A Composite

The current crop of new cars presents a host of innovations with respect to their metallurgical design—the metals, alloys and metal-forms or fabrication processes used in their construction. Among the highlights are the use of an all-welded steel structure for one brand new car, the installation of extremely thin-babbitt-lined bearings, further extension of the use of die castings and additional employment of plastics, under the hood as well as externally.

Weldings, Castings and Forgings

A very good review of all the new design features of the '41 cars is given in *Product Engineering* ("Automobiles of 1941," Vol. 11, Oct. 1940, pp. 465-488), and in *S.A.E. Journal* ("1941 Car Design Trends," Vol. 47, Nov. 1940, pp. 445-460) from which the following items concerning metals and metal-forms have been gleaned.

The new Nash 600 features an all-welded steel construction, and is designed on the aircraft principle of using the body as a load-carrying member. This design is said to have reduced dead weight by 500 lbs.

Other interesting uses of welding are Chevrolet's all-steel-welded seat frames, replacing the usual wood bottom frame. Steel tubing is combined with a deeply ribbed steel stamping to give the maximum strength with minimum weight. Pontiac's front seat frames are also entirely of steel, reinforced with a steel tube that follows the top edge of the framework.

Iron castings are employed for Packard cylinder blocks, relatively low-carbon nickel alloy cast irons having been selected. The material is so hard as to make valve seat inserts unnecessary. In the Chevrolet, rocker arms this year are made of ArMaSteel castings, of sufficient wear resistance to permit elimination of the usual bronze bushings. The arms are diamond-bored to operate directly on the shaft. Cadillac now uses an alloy iron cast camshaft in place of the former steel forging.

But forgings are having their day, too. The front suspension of the series 90 Buick has the kingpin support boss forged integral with the knuckle support, replacing the caster adjuster assembly previously used. Likewise, the vertical front wheel support on the Packard is a steel forging carrying the front wheel spindle, and yoked to the upper and lower support assemblies. These are, of course, in addition to the innumerable forgings customarily used throughout all automobiles.

In the Cadillac, the valve-lifter unit this year is made of case-hardened steel instead of cast iron, with increase in wear resistance and freedom from galling. Packard's former all-cast-iron brake drum is now a steel shell on whose braking surface is centrifugally cast a wear-resistant nickel alloy cast iron.

Intake valves on the Packard are made of chromium-nickel steel and exhaust valves and valve stems of austenitic steel. Aluminum bronze piston pin bushings are used in the new Pontiac in place of ordinary bronze, to resist corrosion by oil constituents at high temperatures.

Bearings and Engineering Finishes

Chrysler engineers have adopted 0.004 in. babbitt-lined-bearings bonded directly to the steel back for Chrysler, De Soto, Dodge and Plymouths in place of former types with 0.015-0.025 in. babbitt. The new Buick bearing, a high-lead babbitt 0.001-0.002 in. thick, bonded to a sintered powder matrix on a steel back, has been described in our Oct. 1940 issue, p. 471.

Cadillac wrist pin fits are improved by "bearingizing" the holes, a process in which the hole is diamond-bored to size, anodized, and the anodic oxide is then cold-worked into the wall by the action of a many-toothed cam; this gives a mirror-finish surface with longer life for the oxide.

"Granodizing" is employed to increase the wear resistance of Chevrolet shifter yokes, and of the diamond-bored rocker Chevrolet arms of ArMaSteel mentioned above. Plymouth's piston pins are tin-plated this year. Hudson continues to silverplate its electrical contact points to prevent corrosion and prolong trouble-free operation.

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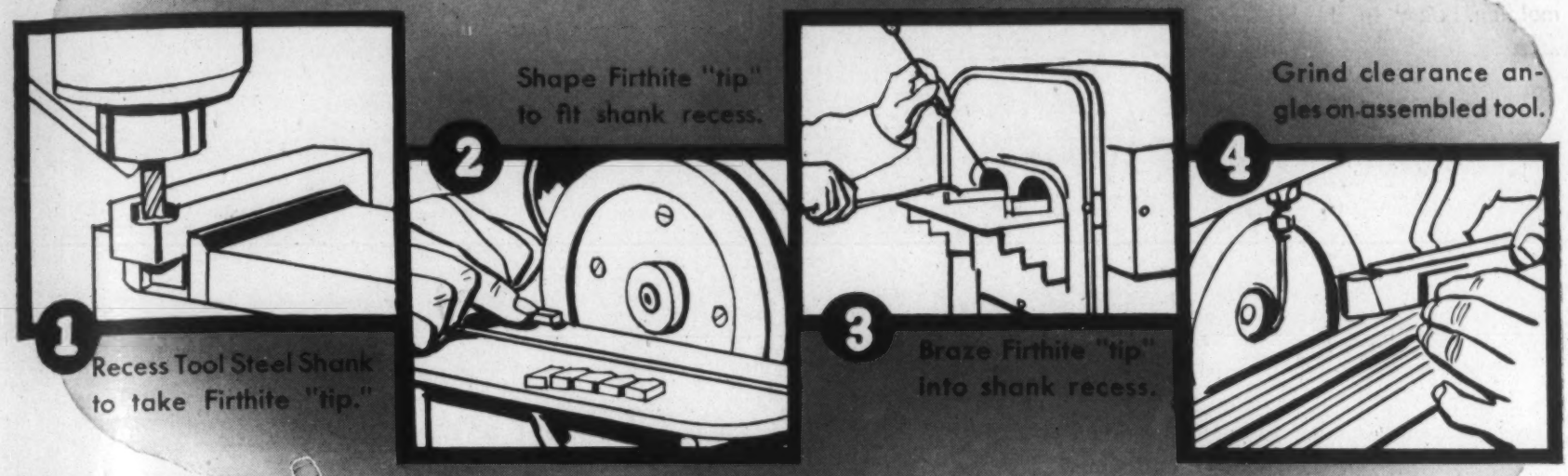

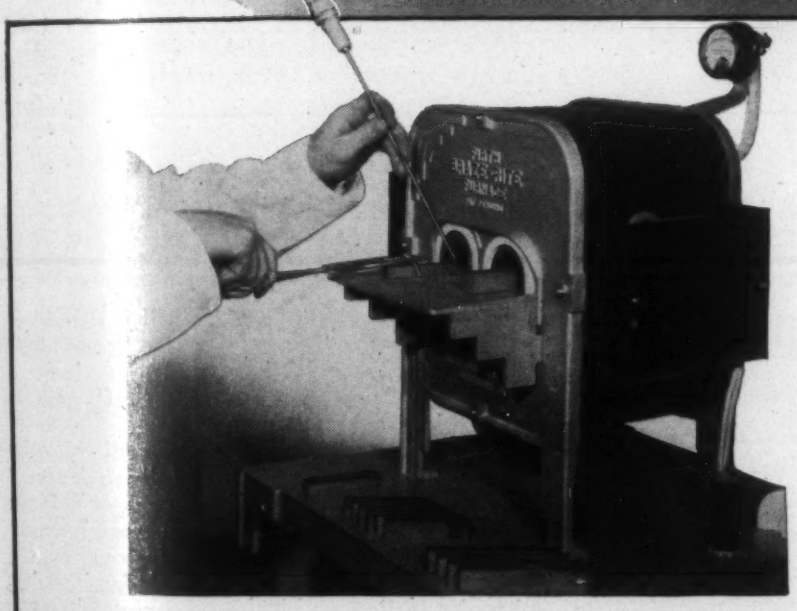

For tool rooms or plants not equipped with apparatus for brazing single point tools, Firth-Sterling offers 2 models of BRAZE-RITE Furnaces specially designed for this work. Information about this equipment, as well as equipment for brazing multi-tipped tools, is available upon request.

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All Packard transmission gears are carburized. Now standard equipment on all Chrysler Corp. cars are grooved spring leaves of Amola steel; the longest 4 or 5 leaves have the surfaces that are exposed to the greatest tensile stress shot-blasted to improve fatigue strength.

General Motors cars are all using much more chromium-plated trim than formerly, although stainless steel trim is still very much in evidence on all new cars. The DeLuxe Ford and Mercury models have stainless trim at the joints of the new 3-section fenders; much extruded plastic trim is used on the Ford, Mercury and Lincoln Zephyr. The center trim on the Studebaker hood is chromium-plated stainless steel, and snaps on to the pointed molding bolted to the hood.

Die Castings

Die castings have gained even more ground in this year's models, the most notable conquest being Chevrolet's switch from a stamped radiator grill to a 6-section zinc alloy die casting. This and other new die-castings applications are cited in *Steel* ("Die Castings Shine in '41," Vol. 107, Nov. 25, 1940, pp. 62-63, 65). Except for front and rear bumpers, die castings dominate among plated external parts, and there are a greater number of "hidden" die castings (requiring no plating) than ever before.

The Oldsmobile steering wheel gear-shift assembly has a zinc die cast housing force-fitted over steel tubing. The lower edge of the die casting is peened over a groove in the tubing. There is a generally increased use of direction signals with die cast housings for control parts on the steering column and for the signal lights. Buick's use of 2 carburetors in its "compound carburetion" further increased the "under the hood" applications of die castings.

Cadillac for the first time is using wide interior die cast moldings at the belt line. Exterior moldings in some models extend across fender skirts and wheel covers. Buick and Oldsmobile are among cars having die cast fittings on the fenders to provide high-lighted "speed lines" that accentuate the appearance of length and speed. A new note is struck by Cadillac in its use of a combination casting for the gas tank filler cap.

Other new uses for die castings are in reflector housings for "courtesy" lights and bezels for dome lights. As heretofore, die cast instrument frames are popular, and die cast radiator grilles most prominent in front end styling.

Plastics

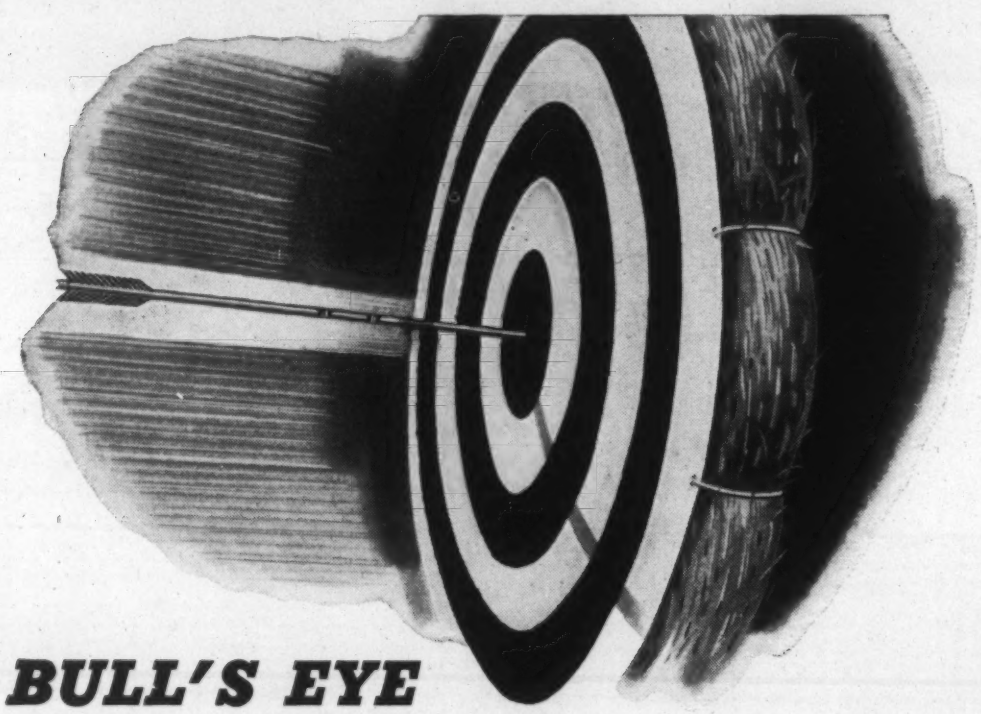
Plastics continue their forward march, with most of the new applications in the instrument boards. Plastics compete with various materials: with applied finishes for some components; with glass, for example, in the Oldsmobile instrument-assembly lens; with rubber for insulation and with hard rubber for molded-over-steel steering wheel surfaces; with metal trim and metal-forms in a variety of places.

According to *Modern Plastics* ("Plastics on Wheels," Vol. 18, Nov. 1940, pp. 29-35, 84), the most notable trends are the increasing number of the strong laminates; the extensive *exterior* use, in addition to already widespread interior use, of molded parts, the application of continuous-length extruded thermoplastic material for trim the use of metal inlaid in a thermoplastic material for nameplates; and the initial use of lignin in combination with other materials for gaskets.

The "laminates," with tensile strength up to 15,000 lbs./in.^{2} and compressive strengths of 49,000 lbs./in.^{2} are used, for example, in timing gears, cam shaft washers, and distributor breaker arms. In the last, one type of arm made entirely of phenolic plastic with the follower arm formed on one end and the contact point at the other competes with a metal arm having a laminated bushing in one end, contact point at the other, and laminated phenolic follower block approximately at the center.

An interesting advance in the use of plastics is the application of molded lignin in the form of gaskets. The lignin is mechanically mixed with Neoprene or other synthetic rubbers and then molded, and the gaskets so produced, in numerous shapes and sizes, are used on several of the new cars.

A complete list of plastic applications in the 1941 Buick series 50, with the weight of each part, is included, and the "plastic material standards" of the Chrysler Corp. given in detail. FPP (3)



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Nickel Steels and Irons in Farm Tools

"ROLE OF NICKEL IN THE PRODUCTION OF FARM TOOLS." H. L. GEIGER (International Nickel Co.) *Agricultural Eng.*, Vol. 21, Oct. 1940, pp. 399-405; Nov. 1940, pp. 441-444, 449. Survey.

In recent years 2,000,000-4,000,000 lbs. of nickel have been used annually in alloy steels and irons employed in all types

NEW YORK WORLD-TELEGRAM, TUESDAY, NOVEMBER 26, 1940.

Toughening Up Process for America's Future War Planes

The world's largest battery of furnaces for nitriding—a process which develops one of the hardest steel surfaces known— are toughening airplane cylinder barrels in the Paterson, N. J., plant of the Wright Aeronautical Corp. In this photo the cylinder barrels are being lowered into the furnace.

Acme Photos

Encased in sealed containers the barrels enter one of the seven furnaces which can treat 35 tons of parts at a time. When three receptacles are heat treated, the furnace moves on rails to the next three. The plant is the first in this country to adopt line production of aircraft engine parts.

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- Seats for Valves
- Shackle Bolts
- Shafts
- Sockets
- Spindles
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- Sprockets
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Nickel carburizing steels commonly used for tractor gears are S.A.E. 2315, 2515, 3115, 3145, 4320, 4615 and 4820. Other tractor parts such as piston pins, steering worms and sectors, roller-bearings, bearing sleeves, and transmission spline, oil-pump, power take-off, belt pulley, and bull pinion shafts are made of S.A.E. 2315, 3115, 3120, 4320, 4620 and 4820 steels. Among typical applications of S.A.E. 3115 and 4615 steels in the implement group are various types of gears for mowers, corn binders, power-driven corn shellers, ensilage cutters, and roughage mills, and sprockets for grain and corn binders.

Direct-hardening steels are used for parts where tensile and torsional strengths must be higher than provided by the carburizing grades, and where wear resistance is of secondary importance. Their major field of application is in the various types of shafting and in bolts, studs, etc. used in farm tools. Nickel steels suitable for this service are S.A.E. 2330, 2345, 3140, 3240, 3250 and 4340. Plow disks have recently been made of a high-carbon, high-chromium steel, S.A.E. 3160, which has met wear, shock and scouring requirements under the more severe plowing conditions.

A recent plating development for parts such as wire, fence posts and sheets used in combines, threshers, hoppers, bins and fertilizer- and manure-spreaders involves the electrodeposition of nickel on the part to be protected, followed by the electrodeposition of zinc. After plating, the part is heat-treated to effect alloying of the nickel and zinc layers; this provides corrosion resistance claimed to be superior to that of straight hot-dip zinc coating and at the same time sufficient ductility to permit cold forming.

The addition of nickel alone or in combination with chromium or molybdenum to cast-iron has become standard practice among farm tool manufacturers where improved structure and strength are desired and to gain additional properties not found in plain iron. The use of nickel as a chill eliminator probably affects a greater number of parts made of gray iron to a greater degree from the machining standpoint than any other factor in farm tool production. Alloy iron for gears has higher hardness to provide wear resistance and higher strength than plain iron. Various types of gears and sprockets are made of cast-iron containing 2.80-3.20% total C, 1.50-2.00 Si, 0.75-1.75 Ni, 0-0.75 Cr and 0-0.50 Mo.

For exhaust manifolds on tractor motors, cast-iron with 1-2% Ni, 0.25-0.65 Cr, low total C, and 1.40-2.00 Si is used. Valve inserts, pulleys, clutch plates, single-throw crankshafts, cylinder blocks and liners are other parts for which nickel alloy irons are often used. MS (3a)

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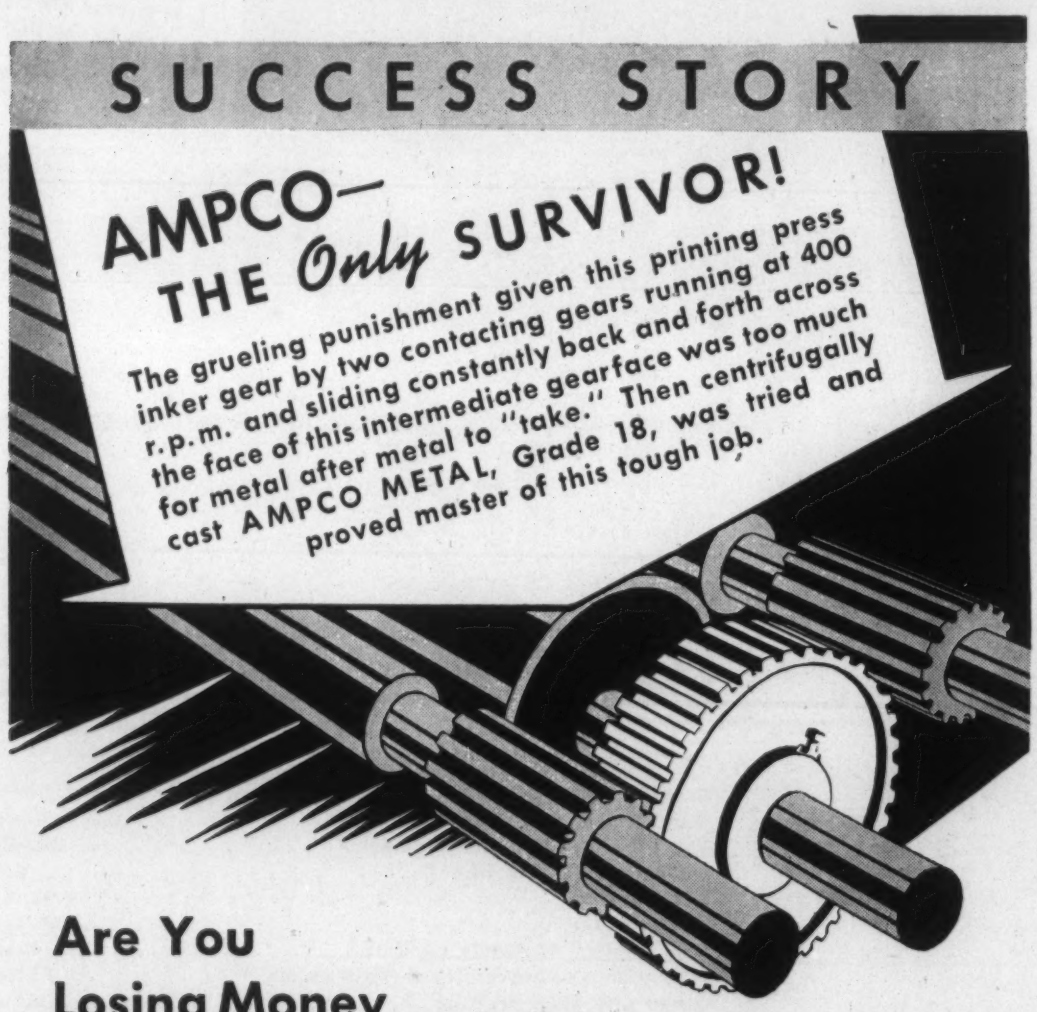

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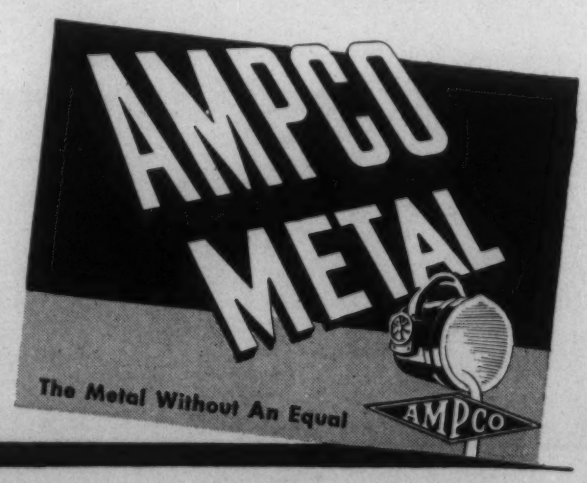

Aluminum Cast Irons for High Temperature Service

"Investigation of the Properties of Heat-Resistant Aluminum Cast Irons." V. I. Smirnov & G. I. Nerovetskaya. *Metallurg*, Vol. 15, Mar. 1940, pp. 13-21. In Russian. Research.

Aluminum alloy irons were prepared, using a standard base iron, to give aluminum contents up to 24% Al. The carbon content decreased with increasing aluminum percentage, and the drop was particularly sharp when the aluminum content was increased from 16% to 18%. For specimens containing 15% or more aluminum, the sulphur was decreased to 0.01-0.02%.

Specimens of ordinary gray iron were not heat-resistant at 1500°-1600° F. Those containing up to 5% Al showed an increased resistance against oxidizing gases but they could not be considered sufficiently heat-resistant from other viewpoints. Specimens containing 5-12% Al were sufficiently heat-resistant while those of over 12% Al were highly heat-resistant. With sufficient aluminum content, the addition of silicon had little effect on the heat resistance.

Resistance to bending decreased gradually up to 13-14% Al and increased gradually with further addition of aluminum. The room-temperature hardness increased smoothly up to 8% Al; for 8-18% Al it changed sharply with a maximum at 12-13% Al; and for over 18% Al, the hardness decreased smoothly.

Specimens containing 8-18% Al had the most satisfactory mechanical properties at high temperatures (up to 1650° F.). For up to 8% Al, the maximum resistance to bending was at 750°-950° F. with a sharp drop at 1300° F. With over 18% Al the resistance to bending decreased smoothly with increasing temperature. Small additions of chromium and nickel had no substantial effect.

Specimens containing 20-24% Al are considered best from the point of view of general scaling-resistance and mechanical properties at high temperatures. BZK (3a)

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Temperature of Test	Yield Point	Tensile Strength	Elongation 2 Inches	Red. Area
+75°F.	53,000 P.S.I.	75,250 P.S.I.	38.8%	74.3%
−50°F.	58,000 P.S.I.	81,500 P.S.I.	37.5%	71.5%

(.505 inches diameter specimen)

CHARPY IMPACT

Temperature of Test	Foot Pounds	Specimens*
+75°F.	69	Charpy Keyhole type
−50°F.	50	Charpy Keyhole type

*Specimens were taken longitudinally to rolling direction.

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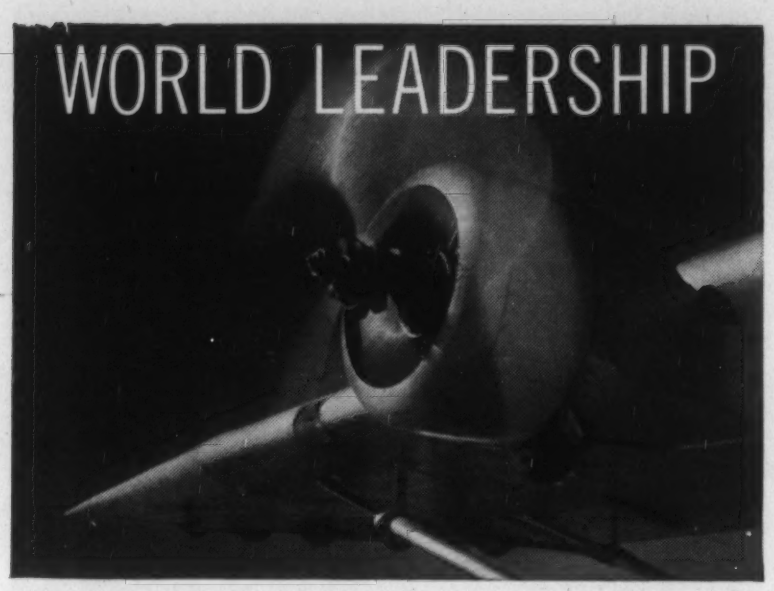

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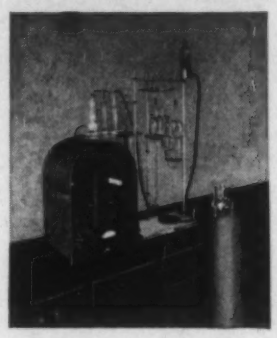

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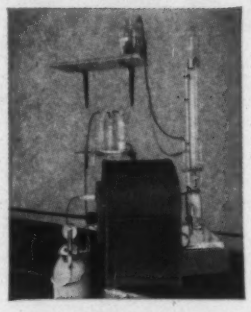

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Fatigue of Pressure-Worked Steel

STEEL COLD-WORKED BY PRESSURE FROM ALL SIDES ("Unter allseitigem Druck kaltgeflossener Stahl") O. FÖPPL. *Mitt. Wöhler Inst.*, No. 37, 1940, pp. 53-66. Research.

The title is a mis-nomer, since steel does not flow under hydrostatic pressure from all sides. What Föppl actually did was to bore a hole in a steel cylinder, cap it by welding and then apply 13,000 atm. of hydraulic pressure. The cylinder collapsed a bit around the hole, and thus produced cold working.

Static tensile tests and hardness surveys across the cross section merely corroborated the fact that cold work was done under these conditions. The idea back of the work seems to be that material about internal flaws might be strengthened by local cold work induced by hydraulic pressure, but Föppl admits that 13,000 atm. is not sufficient to accomplish this.

One interesting observation was made in the course of the work. The hydraulic medium used was a glucose solution colored with Rhodamine B. The solution was forced into the steels, and on standing after release of pressure, the solution would ooze out, evaporate and leave solid glucose on the surface at places about the weld. Sawed-out cross sections of the unwelded, presumably solid portions likewise showed many places where glucose had been driven in. At these internally flawed places the glucose was usually free from dye, which Föppl takes to mean that the rifts in the steel were too small to admit the dye molecule.

On fatigue tests (by the usual non-standard Wöhler Institut method of up-step loading) Föppl states, without citing detailed data, that the endurance of Armco ingot iron was slightly reduced, that of mild structural steel (St. 37) was only a third of the value found on un-compressed material, while that of a stronger structural steel (St. 50) was unchanged, but he admits that the fatigue tests were too sketchy to allow drawing conclusions.

HWG (3a)

Fatigue Properties of Iron Castings

THE BEHAVIOR OF CAST IRON AND MALLEABLE IRON UNDER ALTERNATING STRESSES ("Ueber das Verhalten von Gusseisen und Temperguss unter wechselnder Beanspruchung") A. POMP & M. HEMPEL. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf*, Vol. 22, No. 11, 1940, pp. 169-201. Research.

Tests under alternating tensile-compression, bending and torsional stresses were made on 5 different gray cast irons, one alloy cast iron and a high-grade white malleable iron with flat-planed, notched and drilled samples. The mean stress around which the alternating load was applied was varied from zero to higher values to observe the effect of this change on fatigue strength.

While fracture occurred in tension-compression stressing (with higher mean compression) at an angle of 80°-40° to the direction of force in the cast-iron samples, the fracture in malleable iron took place in an axial direction at right angles to the direction of force; the zones of fatigue fracture and simple static fracture could be clearly distinguished. The torsion fatigue strength of all malleable iron specimens (annealed and not annealed, machined and with casting skin) is (for a mean stress = 0) about 2,000-4,000 lbs./in.^{2} higher than the tensile-compression fatigue strength.

Flat machined specimens of 3 cast irons showed, for both solid and drilled samples, higher bending-fatigue strengths than specimens with casting skin. The ratio, for bending-fatigue strength, of values for drilled flat specimen to those for solid flat specimens varies between 0.50 and 0.78. While tests with solid steel specimens gave a ratio of tensile-compression fatigue strength to bending-fatigue strength of 0.50 to 0.96, [*The low value of 0.50 for steel suggests that the specimen was not entirely free from flexure.*—H. F. M.] the ratio of these values for 6 different cast irons was 0.35-0.58.

In all materials it was found that, although fatigue strength increases with increasing tensile strength, damping capacity assumes higher values as the mechanical strength of the iron becomes lower. Ha (3a)

Alloys to Prevent Strain-Aging

"THE INFLUENCE OF SOME SPECIAL ELEMENTS UPON THE STRAIN-AGING AND YIELD-POINT CHARACTERISTICS OF LOW-CARBON STEELS." C. A. EDWARDS, D. L. PHILLIPS & H. N. JONES. *Iron & Steel Inst.*, Adv. Copy, Oct. 1940, 24 pp. Research.

The influence of carbon, aluminum, copper, nickel, molybdenum, manganese, chromium, vanadium, columbium and titanium upon the strain-age-hardening properties of low-carbon steels was studied.

It was found that these elements can be divided into 2 main groups: those that show little or no tendency to combine with the carbon present in steel (aluminum, copper and nickel) and those that show definite tendency to combine to form carbides (molybdenum, manganese, chromium, vanadium, columbium and titanium). The

former increase and the latter diminish the extent of strain-age-hardening of low-carbon steels.

It appeared that when enough carbide-former was present to combine with all of the carbon present no strain-age-hardening occurred. The amount of chromium required to prevent hardening was approximately 1% and the amount of titanium was approximately 0.2%. When enough of a special element is present to prevent strain-age-hardening no yield-point is observed in the annealed material. JLG (3a)

Bearing Surfaces

"Load-Carrying Capacity Phenomena of Bearing Surfaces." Macy O. Teetor (Perfect Circle Co.) *S.A.E. Journal*, Dec. 1940, Trans. pp. 497-503. Research and discussion of piston-rings and cylinders.

The load-carrying capacity of a bearing surface is dependent upon the surface-layer temperature. Bearing surfaces change in finish and sometimes in structure as surface temperature increases. The surfaces fail to carry the load because the areas in contact reach the melting-point of the material.

Surface finish affects load-carrying capacity, because it determines the actual area and distribution of those areas in contact. There are larger points of contact with smooth surfaces than with rougher ones, the result being that the smoother the surface the less the load-carrying capacity. It is only when the high-temperature areas get too large to cool instantaneously that failure occurs.

Materials such as tin, which will return to their original structures after having passed through critical temperatures, are well suited for surfaces that must operate under conditions of boundary lubrication and for surfaces that distort and concentrate excessive pressures on small areas. But such materials are not necessarily durable: oxide coatings (such as Ferrox) are more durable, since they do not melt—failure of oxide surface occurs when the iron under it melts.

Ferrous metal surfaces change in structure when they melt and cool. Iron carbide has been found on the surface of scored cylinders and rings. Such a surface under operating conditions can receive a perfect oil-quench heat treatment. This change in structure together with change in hardness probably accounts for erratic change in wear rate as wear takes place.

Scuffing tests were made with run-in samples. In tests with cast-iron cylinder samples identical in structure and honed to a smoothness of 4-6 micro-in. and cast iron ring samples identical in structure but with different face finishes, the smoother ring sample surface indicated a lower surface temperature at a given load than the rougher surface. However, the smoother surface had less maximum safe load-carrying capacity. The rough surface has greater load-carrying capacity because of the ability of the small areas in contact to cool before reaching the melting point.

Tests on another machine indicated that load-carrying capacity in lbs./in.^{2} of a bearing surface decrease as the contacting area increases. Results of tests of load-carrying capacity of different-width ring samples carried out on the scuffing machine also indicate that this statement is true. Therefore, it is apparent that load-carrying capacity in lbs./in.^{2} can be increased by dividing a bearing surface into small areas. Further improvement can be effected by cutting grooves or cavities in the surface and filling them with black magnetic iron oxide. MS (3a)

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3b. Non-Ferrous

Aluminum Diesel Engine Parts

"Applications of Aluminum in Diesel Engines." Frank Jardine (Aluminum Co. of America) *S.A.E. Journal,* Vol. 47, Dec. 1940, Trans. pp. 520-525. Descriptive review.

Increasing demand for lighter Diesel engines is necessitating the use of aluminum for major Diesel-engine castings. The National Supply Co.'s latest design of conventional light-weight high-output Diesel engine has aluminum cylinder heads, cylinder block, crankcase, pan, gear cover, fly-wheel housing, rocker-arm cover, supercharger housing and impellers, pistons, bearings, cylinder sleeves, valve seats, camshaft gears, and other parts. It weighs approximately 7.8 lbs./h.p. dry.

Aluminum units were substituted for ferrous parts, with no fundamental change in engine design or manufacturing practice. When replacing standard iron- and-steel-engine by aluminum, new patterns should be built for the major parts. Each of the parts should be redesigned for use in aluminum. It is necessary to increase some sections to insure satisfactory rigidity. As aluminum is somewhat more sensitive to sharp corners than iron or steel, sharp corners should be eliminated and large radii used to insure against stress concentrations where fatigue cracks might start. When replacing a steel part, it is usually necessary to use an aluminum forging.

Aluminum alloy bearings show no signs of corrosion in any commercial lubricating oil, carry as heavy a load as the best bearing materials being used today in standard Diesel engines, and show no danger of bond fatigue. Aluminum cylinder heads permit improved performance, as the metal has better thermal conductivity than iron, and, therefore, eliminates hot spots and heat problems. Water passage between valves and around nozzle is provided by an aluminum tube cast in place. The aluminum engine will not increase corrosion difficulties over that already experienced with cast-iron.

There are a number of small parts that can be made of aluminum without any change in section and using the same patterns as used for iron, with a small amount of waxing. Practically all aluminum parts replacing iron can be made to fit the same jigs and fixtures. When machining aluminum, cutters should be changed and cutting speeds increased to obtain the best results. When necessary, however, aluminum parts can be machined on the same line as the iron parts without tool change. MS (3b)

Copper at High Temperatures

"The Effect of Impurities on Some High-Temperature Properties of Copper." E. R. Parker (Gen. Electric Co.) *Preprint, Am. Soc. Metals,* Oct. 1940, 12 pp. Research.

Stress *vs.* time-for-failure tests were made on an oxygen-free, high-conductivity copper at 390° F. and on an oxygen-free copper containing 0.054% silver at 480° and 390° F.

Samples of both coppers water-quenched from 1560° F. were much more susceptible to intergranular failure under sustained loads at high temperatures than were furnace-cooled samples. The difference is explained as being due to a difference in concentration of impurities in the grain boundary material resulting from the variation in cooling rate. Higher silver concentrations in the grain boundaries result in a strengthening at elevated temperatures. Small quantities of other elements in copper can produce effects similar to those produced by silver.

Oxidation is known to affect the high-temperature strength of steels, but the role oxygen plays in copper remains to be determined. The low recrystallization temperature of tough pitch copper is at least partly attributable to the presence of the oxide particles. These particles apparently act as stress-raisers and cause more than average strain in the surrounding metal during cold working.

Cold-rolled oxygen-free copper containing 0.054% Ag was found to precipitation-harden slightly when heated to 212°-390° F. The precipitation occurring in the cold-rolled copper containing silver is responsible for its high recrystallization temperature. EF (3b)

Creep of Lead

"Creep and Recrystallization of Lead." Albert A. Smith, Jr. (Am. Smelting & Refining Co.) *Metals Tech.,* Vol. 7, Sept. 1940, 7 pp. Original research.

The creep properties of high-purity lead (99.9998+ Pb) were determined at temperatures of 30, 55 and 100° C. It was found that creep of lead does not necessarily proceed uniformly but may take place in intermittent steps. At comparatively high rates of extension recrystallization occurred while at lower rates none could be detected.

When recrystallization is a factor, creep rates are greater than would be indicated by extrapolation from the low-rate part of the log-rate log-stress curve. Employing the method proposed by Kanter, the energy value of 16,500 cal./gram mol is obtained, which is considerably different from the value of the heat of self-diffusion of lead. JLG (3b)

a.C.f.

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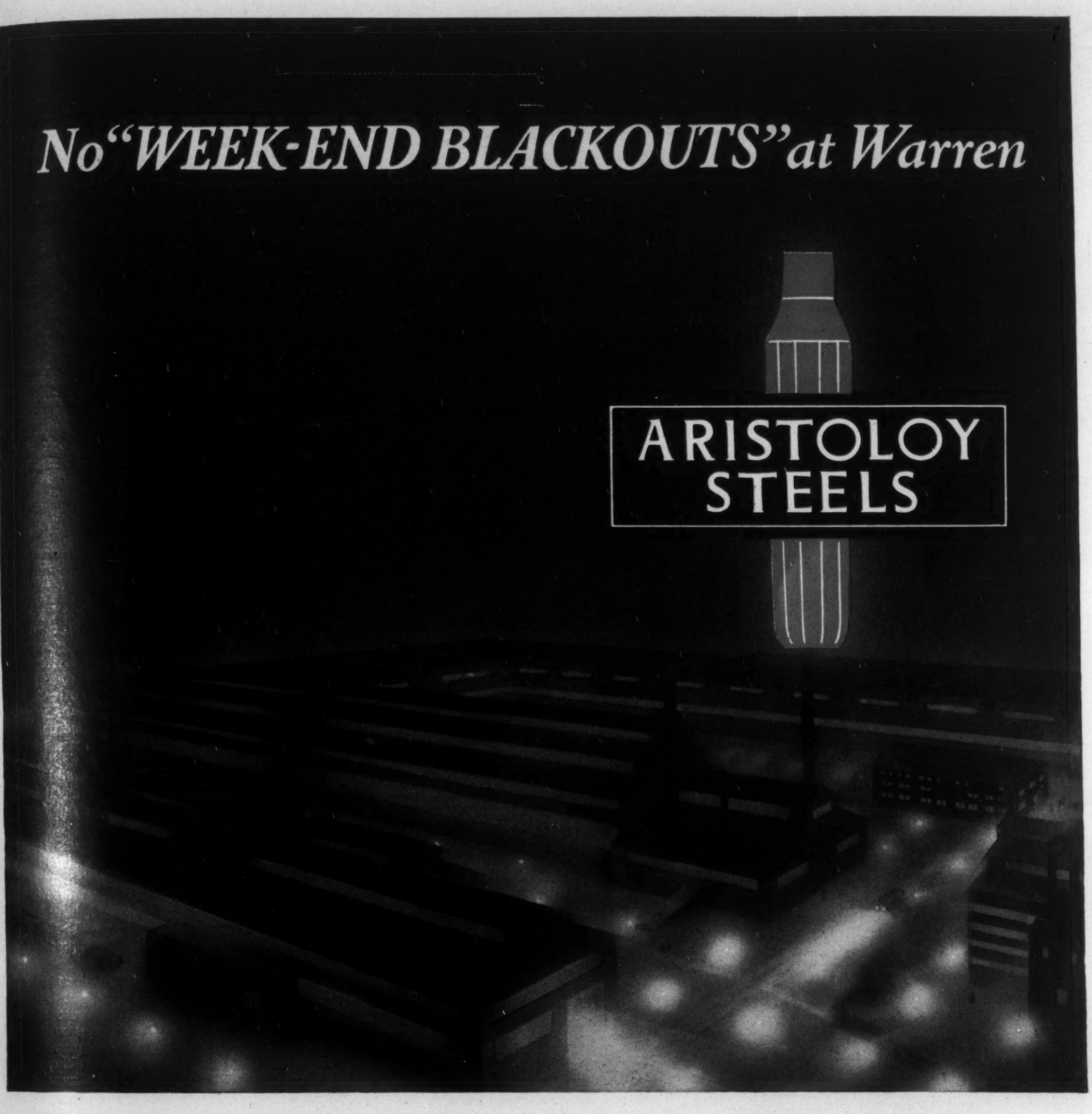

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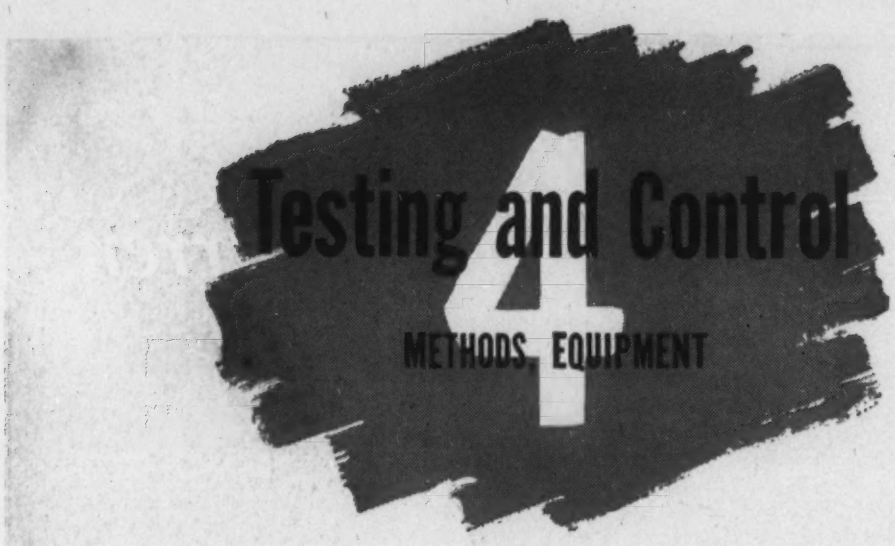

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Non-Metallics in Aluminum

"Progress in Research and Control. Non-Metallic Impurities in Aluminum." *Light Metals*, Vol. 3, Dec. 1940, pp. 296-300. Descriptive.

There are several minor impurities in aluminum to which very little attention is ordinarily paid. As is the case, however, in other metals, small amounts of impurities may create an effect out of proportion to the concentration of the elements involved. In remelting, and hence in scrap, many of the non-metallic impurities in aluminum increase in amount, and their presence may well cause some concern.

Aluminum oxide: The oxidation of aluminum during melting creates a thick film of the oxide at the surface of the melt. The oxide accumulates in the crucible from previous melts, but can be removed to a large extent by stirring the melt with a fluoride-containing flux cover. A reducing atmosphere aids in preventing further oxidation, but does not reduce the oxide already present.

Another source of Al_2O_3 is thermite type reactions with heavy metal oxides present in the charge during melting down. Deoxidation with an alkaline earth or an alkali metal is possible, but the active alkali oxide formed must be removed with a suitable flux in order to be free of possible corrosion difficulties. The effect of oxide inclusions depends upon their size, shape and distribution. Large pieces will result in local weakness, and may give rise to blistering of the sheet during rolling.

Analysis for aluminum oxide may be carried out by the dry method in which metallic aluminum is volatilized as the chloride by chlorine or hydrogen chloride gas, the residue being alumina, iron and silica. In the wet methods, dilute hydrochloric acid is often used to effect solution, the assumption being that aluminum oxide is unattacked. This would hold true for alumina formed during melting, but not for hydrated oxides.

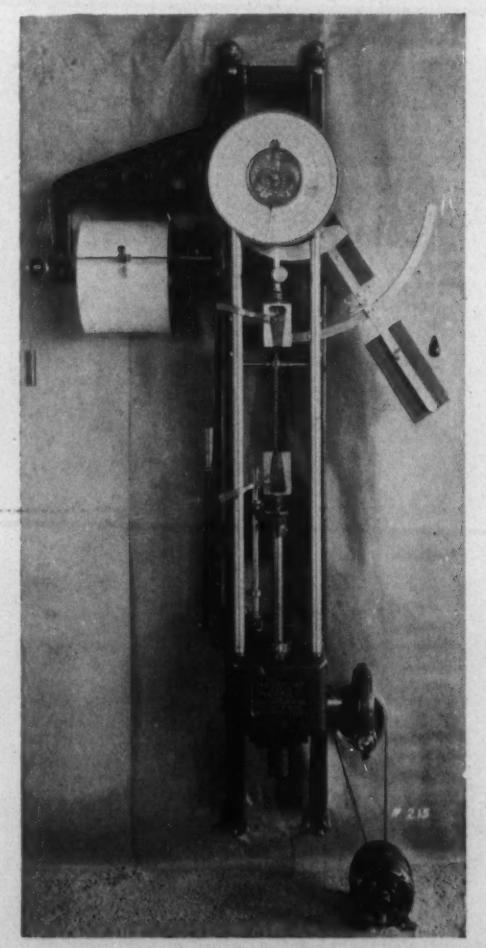
Silica: In the lowest grades of aluminum the silica content is two or three times the alumina content, while in medium grades of the metal, the silica and alumina are about equal, and in the highest grades, the silica content approaches zero. Silica may be determined from the residue obtained for the alumina analysis. Silica is formed by oxidation of silicon in the charge at the surface of the melt. While no research appears to have been directed toward studying the effect of silica on the mechanical properties of aluminum, it appears likely that its effect would be very similar to that of alumina. Both oxides would tend to reduce the coherence of the metal and facilitate cracking during rolling and forming operations.

Nitride: Atmospheric nitrogen reacts slowly with aluminum, to form aluminum nitride. The nitride is readily decomposed by moisture. Only minute traces of nitrogen, of the order of 0.0006% N, have been found in commercial aluminum. The effect of nitrogen in aluminum, if appreciable, is unknown.

Carbon: No work has been done upon the effect of carbon on aluminum, but it can be assumed that it would cause some brittleness, and carbide inclusions will be attacked by moisture and cause pits. The wet analysis for carbon offers difficulties because of the formation of hydrocarbons that escape oxidation unless due precautions are taken. On the other hand, the dry method gives figures that are more or less proportional to the state of subdivision of the aluminum filings. Aluminum oxide coats the grains and prevents complete oxidation of the carbon.

A vacuum solution method has been developed in which the sample is dissolved in alkali in a partial vacuum, the hydrogen and other gases evolved being collected, exploded with oxygen, and the carbon dioxide content determined. The residue in the flask is collected, and the carbon determined by the dry combustion method. However, here again it is suspected that not all of the carbon in the residue is found, owing to the blocking action of aluminum oxide.

Sulphur: Sulphide inclusions have been observed in aluminum. The insolubility of aluminum sulphide would tend to promote corrosion, and the sulphide is readily decomposed by water. *Phosphorus* may be introduced into the metal by the phosphoric



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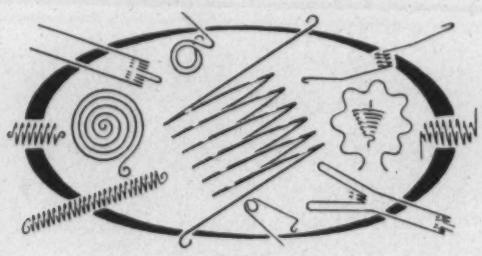

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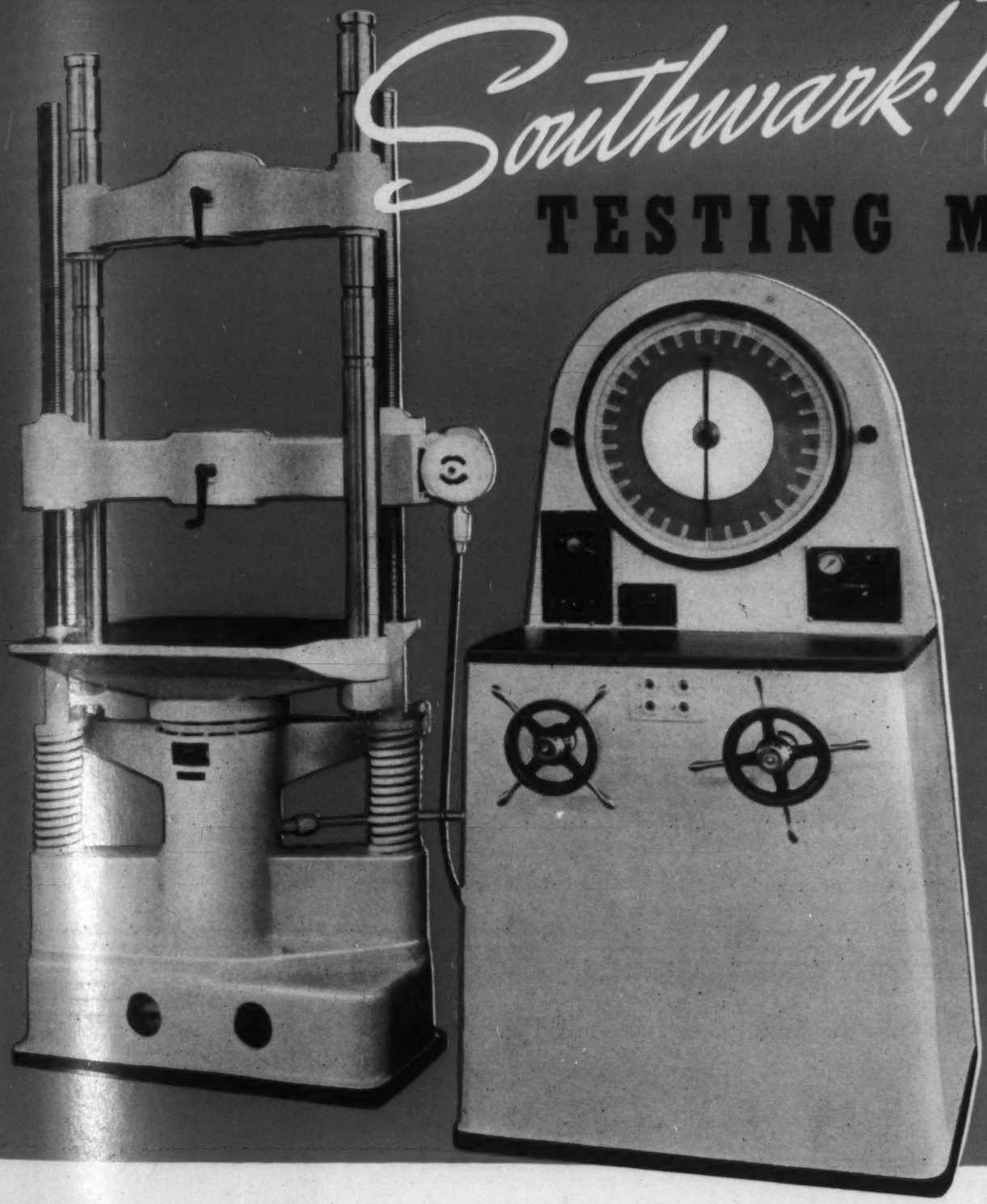

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acid used to protect the carbon reduction anodes from oxidation. Two samples of commercial aluminum were found to contain 0.0018% and 0.0011% P. Aluminum phosphide, like aluminum sulphide, is decomposed by water. Phosphorus is determined by dissolving the sample in acid, and oxidizing the phosphine evolved by an oxidizing solution such as bromine water, and determining the phosphoric acid.

Most of the effort in regard to non-metallic inclusions in aluminum has been expended on methods of analysis. There is still much unknown about the type and magnitude of the effects exerted by such impurities. The fact that high-purity aluminum has markedly different properties from those of the regular grades of the metal leads one to suspect that much of this difference may be due to the absence or presence of non-metallic impurities. AUS (4)

Magnetic Inspection Apparatus

PROGRESS IN APPARATUS FOR THE MAGNETIC FLUX TEST METHOD ("Fortschritte im Bau von Hilfsmitteln für die Magnetpulverprufung") E. A. W. MULLER. *Siemens-Z.*, Vol. 20, Mar. 1940, pp. 49-55. Descriptive review.

Progress has been made through the introduction of tilting chucks for machines with longitudinal, transversal or both types of magnetization. The test specimen can be turned while the current or magnetic field is on. This permits convenient inspection and exposure of all sides to the oil stream. Best results are obtained if the surface to be rinsed is under only a slight angle with the horizontal position.

A new design embodies mechanized chucks for handling large pieces. The magnet pole pieces which also carry the coils are mounted on movable carriages. Thus the length of the flux lines can be adjusted according to the length of the individual pieces to be tested. Also, if high-amperage current is used, the current is confined substantially to the specimen and the transformer output is utilized fully.

Special design features include motor drive for the turning chucks and safety switches to prevent arcing. Hollow parts, such as sleeves, are tested by putting a water-cooled conductor through the bore. Inside surfaces, and (if the wall thickness is not excessive) outside surfaces as well are tested in this way. For the inspection of small parts in mass production a tester has been developed which magnetizes the parts and uses the residual magnetism. RPS (4)

Air-Operated Control Instruments

"PNEUMATIC INSTRUMENTS FOR AUTOMATIC CONTROL." J. B. MCMAHON (Foxboro Co.) *Compressed Air Mag.*, Vol. 45, Dec. 1940, pp. 6311-6316. Descriptive.

For the controlling medium, the majority of automatic controllers employ either air or electricity, and each type has characteristics favorable to its use in certain applications. In many instances the prospective purchaser must decide between them.

The advantages of air-operated control are many. Air-operated control is infinitely flexible and provides for perfectly smooth shading from one control position to another; air systems, too, are simple, completely safe in any atmosphere, and give better protection against loss of control in case of supply failure.

About 65% of industrial control problems can be handled by "open-and-shut" controllers, with about 35% subject to proportional or "throttling" control. In open-and-shut control, or two-position control, the controlled valve is either "open" or it is "shut"; in throttling control the valve is never completely open or completely shut, but throttles the controlled gas or liquid by being in some position between "open" and "shut."

The same element in an air-operated recorder-controller that does the measuring also operates the control mechanism and guides the recording pen. In one simple instrument, for example, a "bulb" located in the space whose temperature is to be controlled contains an expansible fluid, and the whole is connected to a hollow helical spring inside the controller. As the temperature goes up, the fluid's vapor pressure increases and tends to uncoil the spring, which operates the recording or indicating pen or needle.

The motion of the helical spring brings a "flapper" (a rigid metal strip) attached to it up against a nozzle and shuts off a jet of air bleeding from the latter. This causes back-pressure to build up and to expand a metal diaphragm, which closes a tiny valve in the "air relay" and permits a carefully calibrated spring in the controlled fuel valve (say) to close the valve.

Compressed air, as an operating medium, also makes possible pneumatic systems for the distant transmission of measurements or control. The engineer may thus have constant knowledge of conditions at remote or inaccessible points of measurement, or may centralize at one point the actual control of operating units wherever located. FPP (4)

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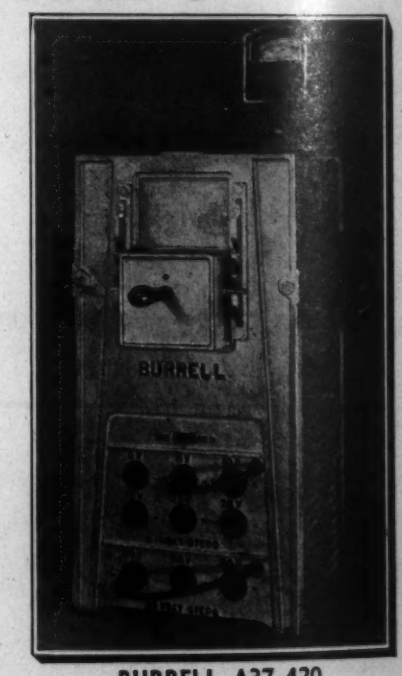

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Spectrographic Analysis for Zinc

SPECTROGRAPHIC DETERMINATION OF 0.30-0.01% ZN IN SILUMIN WITH THE FUESSNER SPARK ("Die spektrographische Bestimmung von 0.30-0.01% Zn im Silumin mit dem Feussner-Funken") H. CORRELL. *Aluminium*, Vol. 22, Oct. 1940, p. 525. Investigation.

Renewed determinations of very small amounts of zinc in aluminum-silicon alloy showed that the previously questioned accuracy of such quantitative determinations with the zinc line 3345 is for all practical purposes quite satisfactory. The difference in the blackening of the photographic paper was sufficiently distinct to give adequate deflections of the galvanometer in determinations based on measurement of the depth of blackening. The evaluation is best made by plotting the galvanometer deflections on log-log paper. Ha (4)

Life Tests on Resistance Wires

"DURABILITY IN LIFE TESTS ON NICKEL-CHROMIUM WIRES." P. J. HIGGS. *Metal Treatment*, Vol. 6, Autumn 1940, pp. 111-115, 127. Investigation.

When nickel-chromium wires are heated to high temperatures in air they deteriorate, and this deterioration is accompanied by changes in various physical properties. The primary object of these experiments (at National Physical Lab., England) was the identification of that physical property whose measurement gave the best indication of relative service durability of different wires.

Four commercial nickel-chromium (80/-20) wires were tested by coiling samples around a grooved 1.5-in. o.d. silica tube and placing in electrically-heated tubular furnaces (the samples thus being indirectly heated chiefly by radiation rather than by direct passage of current through them). The treatment comprised: Heating for 18 hrs. at 1832° F. (preliminary exposure), followed by 14 days at 1832° F., followed by 14 days at 1922° F.; twice a week the samples were cooled to room temperature and then brought back to test temperature; during exposure to the high temperature a current of 2 amps. a.c. was imposed on the wire, enough to raise its temperature about 35° F.

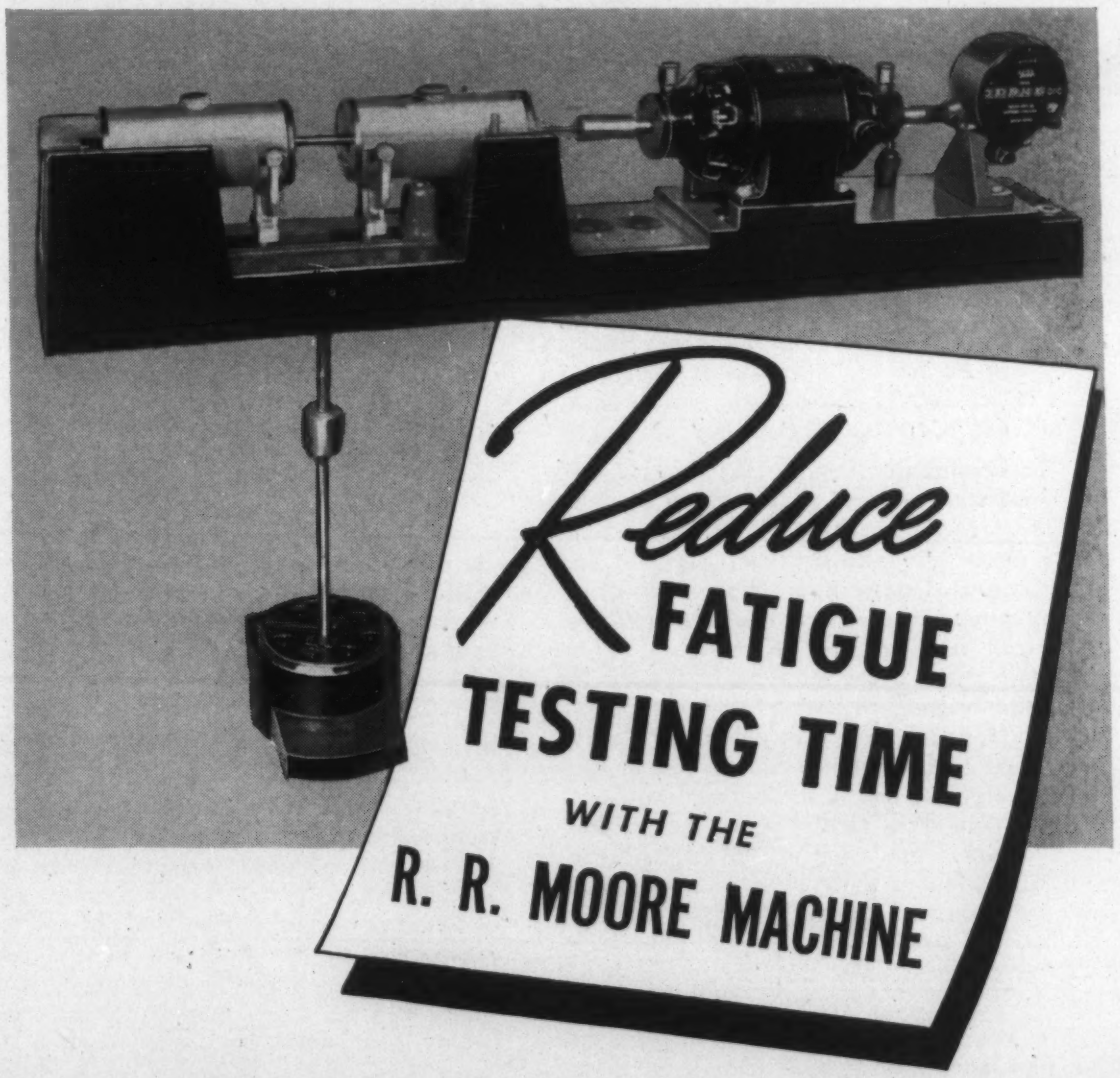
Observations were made of electrical resistance at room temperature and at 1832° F., of surface condition, of length change, of temperature coefficient change, and of mechanical property changes with passage of exposure time, and the thus-obtained ratings of the samples compared with those given by the A.S.T.M. life test. Surface condition changes can be used for rating specimens only when gross quality differences exist. Change in room temperature resistance, change in length, and mechanical property changes are generally unreliable criteria of durability. Change in resistance at 1832° F. is a fairly reliable criterion, if care is taken to avoid measurement errors.

By far the best criterion of durability in the furnace-exposure test is the change in temperature coefficient of resistance (over the range 70° F.-1832° F.) during the exposure. Careful plotting of temperature coefficient changes during the 1832° F. exposure and the 1922° F. exposure indicates that the rate of increase of temperature coefficient for each specimen is virtually constant so long as exposure conditions are unchanged, and that the order of quality of the wires (using the A.S.-T.M. test ratings as standard) may be obtained for any one temperature from temperature coefficient curves covering exposure periods of 100 hrs. or less.

Thus, this furnace-exposure test, using temperature-coefficient - of - resistance stability as the criterion of merit, rates the specimens tested in the same order after 100 hrs. as does the A.S.T.M. test after 400 hrs. at 1950° F. [*This comparison is a bit unfair, for the A.S.T.M. test as now conducted heats 80/20 wire to 2150° F., at which temperature the test on a good wire will take about 200 hrs.*—F.P.P.] The increases in mean temperature coefficients, too, are so large that particular accuracy in measurement is not essential.

Beyond this, the furnace-exposure test is claimed to approach service conditions more closely than the A.S.T.M. test, since the latter imposes a creep-producing stress on the hot wire and involves far too many heating-and-cooling cycles, and because the furnace exposure test includes contact with ceramic whereas the A.S.T.M. does not.

[*The "suspended-weight" feature of the A.S.T.M. test has been previously characterized as a serious disadvantage in these columns (Aug. 1940, p. 216), but with specific reference to comparisons between iron-base and nickel base alloys, rather than just nickel-base. Higgs' contention that the A.S.T.M. test is less representative than the furnace-exposure temperature-coefficient-measurement method is peculiarly academic, since in his article he offers the new test on the basis that it rates materials in the same order as does the standard test.*—F.P.P.] (4)



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Furnace Atmosphere

COMPOSITION OF FURNACE ATMOSPHERES RESULTING FROM PARTIAL COMBUSTION OF GASEOUS FUELS. *By Committee on Industrial Gas Research. Published by American Gas Assn. Testing Laboratories, Cleveland, 1940. 6½ x 10 in., 96 pages. Price $1.25.*

The importance of controlled atmospheres for heat treatment is indicated by the publication of this extensive study. The revenue to the gas industry from gas sold for preparation of controlled atmospheres must be picayune compared to that for fuel for industrial heating. The Association is to be complimented for studying a matter of vital importance to heat treatment, even though the revenue obtainable by much wider use of controlled atmospheres would not be very important to the gas industry.

Based on experimental data, charts and methods of computation are given enabling the calculation of the composition of a gas when burned with any ratio of that particular gas to air on the side of what the heating engineer calls incomplete combustion.

The main outlines of the facts brought out have been already well known to those specializing in the design and control of equipment for preparation of controlled atmospheres of this type. The booklet makes it easier, even for the specialist, to make the calculations necessary in engineering such equipment, since not only the composition, but the volume produced by any variety of partial combustion is dealt with. The novice will find his task made much easier than if he had to dope the data out from first principles. The user of controlled atmospheres will be less directly interested, but he, too, can gain a better understanding of the reason for the word "controlled," since control is vital in order to get the desired results.

The experimental work was done in small laboratory equipment. It would have been helpful had some of the work been duplicated on a larger scale, and with packed or catalyzed chambers rather than open ones. The conclusions on pages 43-46 that something of the order of 0.10% free oxygen is in equilibrium in the products of partial combustion rather than due to air infiltration into the small scale setup, appear to need verification before acceptance. Likewise, on page 36 it is reported that natural gas in a special type of burner produced flue products free from oxygen. The better types of equipment on the market for the production of controlled atmospheres are generally reputed to give no free oxygen, so it would be well for the A. G. A. to check the laboratory conclusions with commercial results in this particular detail. On the whole, however, the results reported and the conclusions drawn appear dependable.

The study related only to the products of partial combustion as delivered by the burner, and was not extended to the important matter of purification of this gas from water vapor, carbon dioxide, or traces of oxygen. Adequate experimentation on and discussion of this further problem and of the reactions of any carbon dioxide not removed with the hydrogen of the gas, along the lines hinted at on pages 84 and 85, would be more helpful to the steel treater than what has been reported in pages 1-83, but it is logical to postpone that until after the publication of the present contents. It is to be hoped that it is just a postponement and that future work will include these phases.—H. W. GILLETT.

Deep Drawing, Pressing

THE METALLURGY OF DEEP DRAWING AND PRESSING. *By J. D. Jevons. Published by Chapman & Hall, London, 1940. Cloth, 6x9¾ in., 699 pages. Price 50 S.*

This is a contemplative type of book, that is, the author says what he thinks is important and says much of it in other words and in various connections several times for emphasis. Space limitations do not exist for him any more than they did in Carpenter and Robinson's huge volumes on metals. Part of this is due to the aim, despite the title, to make the subject intelligible to producers of deep-drawn objects lacking previous understanding of metallurgy, so that the author goes so far back as to devote a few paragraphs to the blast furnace.

The recapitulation of what metallurgical engineers concerned with the production of stock for deep drawing might be expected to know, will, however, not do *them* any harm and certainly clarifies the subject for those not versed in those lines.

The book covers both steel and non-ferrous alloys, presses, dies, tools (these last two both as to material and as to design and finish), lubrication and lubricants, and discusses at length the problem of laboratory testing for evaluation of deep drawing properties. Insistence is put on the fact that no one test evaluates these properties for all types of deep-drawing. For a comparison that puts different ferrous and non-ferrous alloys in the same general order as they are classed in the mind of the user, Jevons cites with approval the method described by Sommer before the Am. Inst. Mining & Met. Engrs. in 1934 (see METALS AND ALLOYS, Vol. 5, June 1934, p. MA 254).

The production and the pressing of metal for deep-drawing are, to a considerable degree, still arts rather than sciences. Jevons admits this, but doesn't admit that they need continue so. His thoughtful appraisal of the many factors involved will provoke further thought by the reader. Few categorical statements are made, since circumstances alter cases. The author examines each circumstance with care.

The completion and publication of such a book in wartime is a credit to the country of its origin. It should be widely read, for those who know little about the subject will learn much, and those who think they know a lot about it are likely to become less opinionated after they have digested it.

—H. W. GILLETT

Corrosion Protection Bibliography

BIBLIOGRAPHY ON CORROSION PROTECTION COATINGS. *Prepared by Research Laboratory, Standard Steel Spring Co., Coraopolis, Pa. Issued as Document No. 1436 by American Documentation Institute, 2101 Constitution Ave., Washington, D. C., 1940. Available in microfilm (35 mm. standard safety photographic film, comfortably usable in reading machines now widely available) for $1.50; or in photoprints, readable without optical aid for $13.60.*

This is an annotated bibliography of 134 pages, with references through 1939, divided into the following topics:

Corrosion of Metals and Alloys.
Corrosion of Electroplated Metals.
Corrosion of Other Than Electroplated Coatings.
Coatings Other than Electroplated Ones.
Electroplating of Single Metals.
Brittleness and Adhesion of Electroplates.
Pittings and Porosity of Coatings.
Double Plating.
Alloy Systems and Alloys of Special Interest.
Alloy Plating.

In some cases, the title of an individual article describes its contents sufficiently without annotation, but about half of the entries are accompanied by anywhere from a line to a page of comment that picks out the meat of the article. This is a convenient and useful compilation.—H. W. GILLETT.

(Continued from page 238)

Steel Manufacture

THE MAKING, SHAPING AND TREATING OF STEEL. 5TH EDITION. *By J. M. Camp & C. B. Francis. Published by Carnegie-Illinois Steel Corp., Pittsburgh, 1940. Cloth, 6 x 9 in., 1440 pages. Price $7.50.*

"Camp and Francis" was originally written for the information of the non-technical employees of the Carnegie Steel Company, and the 4th edition was published in 1925. Fifteen years has brought many new features that had to be covered, such as continuous rolling, grain size control, creep testing, nitriding, low alloy structural steels, the physical chemistry of steel making, sponge iron, lead for machinability, austempering, etc., etc., which required the addition of 300 pages over the old edition.

In the old edition "stainless steel" referred to the cutlery type and "18 and 8" was not discussed; Aston iron was mentioned in passing with the statement that no data indicative of the quality or nature of the product were available; molybdenum was stated to have been abandoned as a substitute for any material portion of the tungsten in high speed steel.

The present edition brings the discussion more or less up to date, though there are peculiar omissions, such as that of modern controlled atmospheres. The section on cast steel fails to include modern knowledge on the use of aluminum, and the alloy compositions featured scarcely reflect the degree of actual use. The present edition is said to have been rewritten, but the old discussion of "amorphous cement" is left intact. On page 33 uranium is still listed as common in high speed steel, although page 1047 remarks that its use has been abandoned.

New illustrations include those of White-Souther and Upton-Lewis fatigue machines, which most modern authorities would include only as of historical interest. No comment is made on hydrogen as a cause of shatter cracks. On points like these the book does not reflect present-day knowledge to the extent one might expect. One might suggest that in a 6th edition, the accumulated knowledge of Dr. Johnston's research department might be drawn upon to a greater degree. They would not have let slip the statement that the A.S.T.M. suggests that creep tests of copper- and aluminum-base alloys should be conducted over the range 2000-2800 deg. F.

The 4th edition was so good for its time that our expectation that the 5th would be so revised and so completely checked up by competent authorities as to have an equal status, may have been too large for any author to fill. It is a disappointment to find that in some respects the 1940 edition seems rather largely to view matters from the point of view of 1925.

However, it still has the virtues of the 1925 edition in that no other one book covers so much ground on the technology of the whole steel industry, and that no other so well gives the reader an inkling into the production problem of the steel mill. Text books and treatises written by professors and other outsiders inevitably lack the complete production background of this. As a guide to the user of steel products the book has many rivals, but it has no rival in its value for a budding metallurgical engineer who plans to enter the wrought steel industry itself. The matters of importance to him are more completely set forth and the point of view more the one he needs than in any other single text.

For all the steel products of appreciable tonnage, the plant practice from the ore to the point where the product leaves the mill is given, sometimes sketchily, but usually well enough to give the reader the "feel" of things.

The relative space devoted to tonnage products made from carbon steel, without neglecting or minimizing the value of alloy steels, gives the reader a perspective not likely to be gained from current metallurgical literature, nor from the average text book. For this reason, perhaps the conservatism—the 1925 flavor—of parts of the 5th edition, is not wholly a drawback.

Whether the purchaser be a library or a freshman in metallurgy, the volume is worth the $7.50.—H. W. GILLETT.

Iron and Steel for the Novice

IRON AND STEEL TODAY. *By John Dearden. Published by Oxford University Press, New York, 1940. Cloth, 5¾ x 8¾ in., 190 pages. Price $1.75.*

This is one of a series of books—including such topics as Photography Today; Electricity Today; The Cinema Today; etc. —aimed to record technical progress for the general reader. Any attempt to do that sort of thing for metallurgy is interesting. The book is written from the British background—for example, the chapter on wrought iron says nothing about Aston iron. On the other hand, the basic Bessemer process, as now used in Britain, gets a whole chapter, and crucible tool steel about 10 pages.

The blast furnace, the iron foundry, the Bessemer, the open-hearth and the electric processes, casting of steel, working of steel, are all simply described, and brief attention is paid to tool steel, testing, heat treatment, and to varieties of alloy steel.

Excellent photographs of steel plant equipment and operation add much to the reader's grasp of the subject matter. The metallurgy given is sound, this being guaranteed by the fact that the material was checked by H. O'Neill. It is a bit regrettable that the term "inherent" should have been used in connection with fine-grained steel, but that erroneous terminology came from this country, so one can hardly blame the British author.

A high school senior could understand the book, and would get a clear and truer picture than the college freshman is likely to get from the average text book of introductory metallurgy, because this volume is not concerned with technical details or theories, but only with the broad accomplishments in iron and steel.

It is no easy task to introduce a technical subject to a non-technical reader with no background in the subject, so as to be interesting, clear, and accurate. Dearden has accomplished this task, and has avoided the failing of many authors of such books, that of stooping to "baby-talk" in the effort to be simple. If one has acquaintances who wonder what sort of a job a metallurgical engineer has, a present of this book would be in order.—H. W. GILLETT.

Powder Metallurgy

POWDER METALLURGY. A REVIEW OF ITS LITERATURE. *By C. B. Carpenter. Published by Colorado School of Mines. Golden, Colo., October 1940. Paper, 6 x 9 in., 40 pages. Price 50c.*

This carefully prepared monograph (Colorado School of Mines' *Quarterly*, Vol. 35, No. 4) presents in compact fashion the most important data on powder metallurgy published up to about June, 1940. It is really a "correlated abstract" on the subject, with about 60 references covered. Some papers are summarized in 2 or 3 pages whereas others are tied in to the general argument with a line or two of comment.

Although very little attempt has been made to examine the data presented in any critical light, the process of selection seems to have been good, for one recognizes at once that all the best papers and articles have been digested, and the mostly trivial stuff omitted.

The book starts out systematically with sections on methods of producing powders; powder characteristics, grading and testing; pressing; and heat treatment; but system takes a gradual departure in here somewhere and the latter half of the book seems quite without order. For example, one finds a section on "Fields for Powder Metallurgy" on page 19 and another, "The Field for Powder Metallurgy" on page 37. There are sections on sintering, carbides, iron powder metallurgy, carbonyls, electrical applications, PDCP copper, fatigue of compacts, diffusion treatments, etc.

Nevertheless, the material is there and the booklet should be very useful to anyone sufficiently interested to do a little digging. It is by far the most informative brief review of powder metallurgy that has yet been published.—FRED P. PETERS.

Titanium in Steel

TITANIUM AND ITS USE IN STEEL. *Published by Titanium Alloy Mfg. Co., New York, 1940. Cloth, 5¼ x 8¼ in., 113 pages. Price $2.00.*

This is another of the handbooks on specific alloying elements put out by one or another of their producers. Although this handbook, like most such, tends to put the best foot forward, many thoroughly sound and helpful comments and data are given. The topics covered include applications of titanium in rimmed and killed wrought steel, steel forgings, steel castings, low alloy steels and high alloy steels, and methods of chemical analysis for titanium.

Information on the available forms and sizes of titanium alloys and on the impurities carried by the various commercial grades is included.

The book is a welcome and up-to-date summary, nicely printed and well bound.—H. W. GILLETT.

Fabricating and Treating Steel

THE WORKING, HEAT-TREATING AND WELDING OF STEEL. *By H. L. Campbell. Published by John Wiley & Sons, Inc., New York, 1940. Cloth, 6x9¼ in., 230 pages. Price $2.25.*

This book is obviously addressed to engineers and other technical men of non-metallurgical training. The author has covered his field of "Steel" admirably for such purposes and has carefully presented his discussions without confusing the reader with unnecessary elaboration.

A high standard of accuracy is maintained throughout in spite of brevity and but little detailed criticism is called for. Until the reviewer studied spot welds he thought, with the author, that all spot welds were simply pressure welds. The classification of welds and the discussion of spot welds miss the important point of fusion of metal at the interface.

Under "Impact Testing" the author discusses—no, not the effect of an impact, as you might expect,—but, of all things, the effect of notching a bar. Then instead of mentioning what use can be made of notched bar tests, such as correlations with certain types of failures, the author points out what they do not correlate with. This test, more than any other today, needs to be properly explained to engineers. True impact testing should be included even in an abridged discussion such as this is.

This book covers the making of steel, shaping, classification, testing, microstructure, the effects of heat and mechanical treatment, and equipment. It closes with chapters on welding and the protection of steel, and various laboratory exercises. It can be highly recommended and is worthy of a place in the library of every engineer concerned with steel.

—S. L. HOYT.

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Metal Treating with Ammonia

NEW HANDBOOK ON AMMONIA IN METAL TREATING. *Published by The Mathieson Alkali Works, New York, 1940. Paper 6x9 in., 44 pages. Price, free to those interested.*

In view of the National Preparedness Program this book is especially timely, particularly in connection with aircraft and armament production in which ammonia is a large factor in heat treatment.

The first portion deals with case-hardening processes, including nitriding, dry cyaniding and "hydryzing," in which ammonia gas is used directly as a furnace atmosphere and where no cracking equipment is necessary. In the bright annealing and nitriding of stainless steels and in welding processes, dissociated or cracked ammonia is used and various types of dissociating equipment are discussed.

Another section is devoted to the chemical and physical properties of anhydrous ammonia, its handling, production, physiological effects, and so on.

This brief discussion will be of interest to all metal-treating engineers and users of ammonia in any form and can be obtained free by addressing the Mathieson Company at 60 East 42d Street, New York.

—E. F. CONE.

Other New Books

HANDBOOK OF CHEMISTRY AND PHYSICS. 24TH EDITION. *Edited by C. D. Hodgman & H. N. Holmes. Published by Chemical Rubber Publishing Co., Cleveland, 1940. Cloth, 5 in. x 7¼ in., 2564 pages. Price (regular edition), $3.50.* As useful as ever, and some 340 pages bigger than the preceding edition, with several new tables of purely chemical or physical interest. Engineers will welcome a new 18-page table on properties of commercial plastics, but will still wish for modernization and extension of the antiquated 10-page table on composition and physical properties of alloys.

THE ZINC INDUSTRY. *By Ernest V. Gent. Published by American Zinc Institute, New York, 1940. Paper, 6 x 8¾ in., 30 pages. Free to those interested.* A readable review of the production and consumption factors—technical as well as economic—in moving zinc "from mine to market."

DIRECTORY OF SWISS MACHINES, APPARATUS AND TOOLS. *Published by Office for Industrial Information, Geneva, 1940. Paper, pocket-size. Price $2.50.* A well-arranged and indexed directory of Swiss machine tools, precision instruments, gages, etc., printed in English, French, Spanish and German.

PHENOMENA AT THE TEMPERATURE OF LIQUID HELIUM. *By E. F. Burton, H. Grayson Smith & J. O. Wilhelm. Published by Reinhold Publishing Co., New York, 1940. Cloth, 6¼ x 9¾ in., 362 pages. Price $6.00.* An American Chemical Society Monograph. Contains interesting chapters on superconductivity, low-temperature magnetic properties, and electrical and thermal conductivities.

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trends

By Edwin F. Cone, Editor

Tool Steel Classification

There are about 1,000 brands of tool steel on the market, according to the American Society of Tool Engineers. Many of these are identical or nearly so. There are no standards by which the qualities of these multitudinous brands can be judged and classified so that the user gradually drifts into a general use of certain few varieties which afford generally satisfactory results. The American Standards Association has announced that it has been requested by the A.S.T.E. to undertake the classification of tool steels by usage—to index all tool steels by class designation, by manufacturer, by trade name and by classes of usage. A trend toward a classification by types or uses rather than by trade name alone is believed to make the choice of the steel for a particular application a simple matter to the user.

Steel Consumption

Since 1854, says the American Iron and Steel Institute, over 1,760,000,000 net tons of rolled or cast iron and steel have gone into consumption in the United States. About one-third of this total has been repurchased as scrap for remelting into new iron and steel. Of the remaining 1,210,000,000 tons, the greater part is believed to be still in service in this country. An indeterminable part has been exported, and much lost through corrosion, erosion or abrasion.

Extrusion

Stainless steel, nickel alloys, bearing steel, and non-ferrous alloys are now being extruded as tubing, structural shapes and rods due to notable developments in extrusion presses and metallurgical methods during the last 5 yrs., according to a paper by a British engineer, Albert B. Cudebec of the Loewy Engineering Co., Ltd., delivered at the annual convention of the A.S.M.E. in New York early in December. Several such alloys are being extruded in large quantities in Great Britain, he said, but these have not yet been commercialized in the United States. In Great Britain 40 to 50 large metal extrusion plants are in production.

New Steel Capacity

Considerable new electric steel furnace capacity has been added in the past year—estimated as an increase of about 900,000 net tons. This is reported as increasing the electric furnace capacity as of the end of 1939 at least 50 per cent.

Approximately 1,300,000 net tons of additional open-hearth capacity will be added as a result of programs now under way, exclusive of increases due to enlargements of older furnaces.

In Germany

Trends in the German metal and metal-working industries, according to U. S. Commercial attache's reports, include the use of welded instead of cast machinery parts, extensive employment of light metal in machinery construction, tinless cans and tubes, making and molding synthetic plastics, use of aluminum and magnesium to replace copper, nickel, tin and to a lesser extent iron and steel, and more extensive use of remelted aluminum alloys in machinery construction.

Aluminum

Increases in the productive capacity of aluminum indicate an output of something in excess of 700,000,000 lbs. by July, 1942, as compared with the 1939 level of 327,000,000 lbs. says a statement of the Aluminum Co. of America, thus more than doubling in 3 yrs. a production built up over more than half a century. This together with that of others in the industry makes present and planned output adequate for all estimated defense needs, it is believed.

Nickel

Complete data for 1940 will show that more nickel was sold in that year than in any previous year, according to a statement by Robert Stanley, president of the International Nickel Co. of Canada, Ltd. The increase over 1939 occurred principally in the United States where heavy industries, nickel's most important market, were active due to the requirements of the British Government and to the American Defense Program.

Foundrymen

With the exception of the recent depression years, membership growth in the American Foundrymen's Association has been generally upward. In 1896 when this organization was founded, membership was about 400. In 1920 it was over 1,600 and in 1930 nearly 2,500. At the end of last year it was about 3,400—a steady, healthy and deserved expansion.

Operating Rate for Steel Ingots

The trend in American steel ingot production last year was definitely upward. In the first quarter, operations were only 72.6 per cent of the industry's capacity and in the second quarter, 72.7 per cent. In the third quarter, however, the average was 87.9 per cent with the last quarter at close to 95 per cent of capacity.

(Other "Trends" on page 248)

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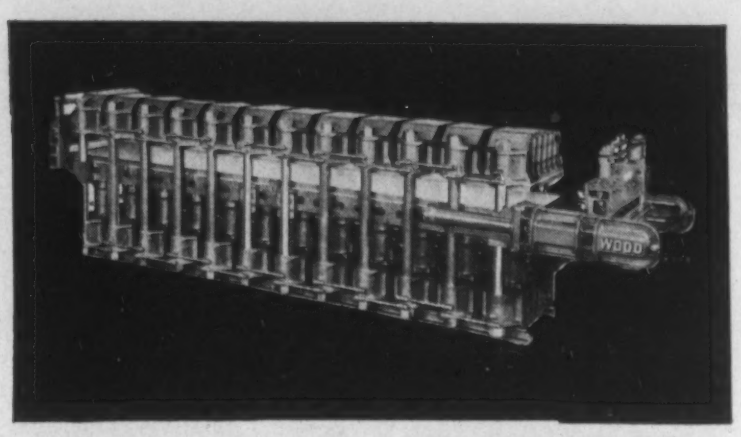

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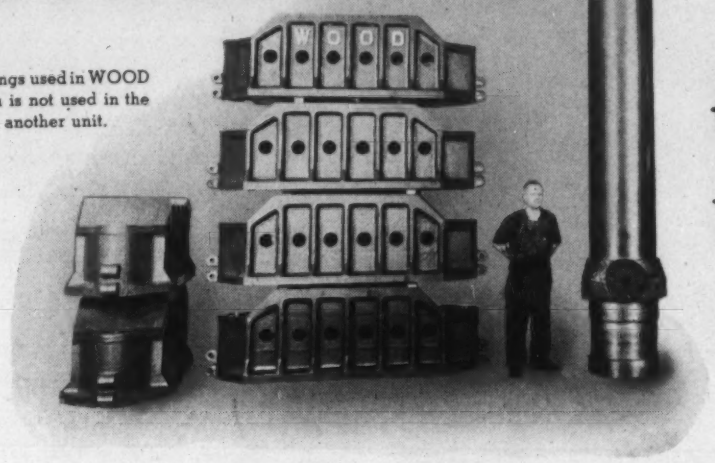

A few *Meehanite* castings used in WOOD presses. The large ram is not used in the press described, but in another unit.

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Cincinnati, Ohio	The Cincinnati Milling Machine Co.
Cleveland, Ohio	Fulton Foundry & Machine Co.
Denver, Colo.	The Stearns-Roger Mfg. Co.
Detroit, Mich.	Atlas Foundry Co.
Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
Irvington, N. J.	Barnett Foundry & Machine Co.
Los Angeles, Calif.	Kinney Iron Works
Milwaukee, Wis.	Koehring Company
Mt. Vernon, Ohio, Grove City, Pa.	Cooper-Bessemer Corporation
New York, N. Y.	The American Brake Shoe & Foundry Co.
Oakland, Calif.	Vulcan Foundry Company
Orillia, Canada	E. Long, Ltd.
Philadelphia, Pa.	Florence Pipe Foundry & Machine Co., (R. D. Wood Company, Selling Agents)
Phillipsburg, N. J.	Warren Foundry & Pipe Corp.
Pittsburgh, Pa.	Meehanite Metal Corporation
Pittsburgh, Pa.	Rosedale Foundry & Machine Co.
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trends

By Edwin F. Cone, Editor

Steel Industry's Raw Materials

When the American steel industry is operating at maximum capacity the following is the quantity of certain raw materials needed and the per cent ordinarily obtained from certain sources, according to the American Iron and Steel Institute:

Material	Net Tons Needed	Per Cent Obtainable from Steel Industry	Other Domestic	Foreign
Iron Ore	95,318,000	80	20	—
Coal	80,316,000	75	25	—
Limestone	25,055,000	53	47	—
Scrap	41,437,000	58	42	—
Manganese Ore	1,506,000	—	—	100
Fuel Oil	5,236,000	—	100	—
Refractories	3,760,000	2	97	1
Ferroalloys	1,112,000	48	48	4
Other Non-Ferrous	399,000	21	54	25

According to these figures the American steel industry can supply approximately 75 per cent of the tonnage of raw materials it consumes in a year of peak operations.

This is not quite correct for manganese. Anaconda will supply about 10 per cent from Montana rhodochrosite in 1941. Some 15 per cent will come from Cuban ore which is really foreign.

Platinum and Palladium

A new use of platinum as leaf for exterior building decoration appeared last year. It is resistant to tarnish and to discoloration by the atmosphere. The use of palladium in the jewelry field in combination with yellow gold has increased.

Scrap to Japan

According to Government data exports of scrap iron and steel to Japan in 1940 declined decidedly. To Nov. 1, the total last year was 962,772 gross tons as compared with 1,720,776 tons to Nov. 1, 1939, a decline of about 44 per cent. With the embargo effective, future shipments will be practically zero.

Coordinating Specifications

Because there are a large number of specification writing bodies and because each has its own pet requirements, making the manufacturer's problem a difficult one and increasing costs to the consumer, Committee B-5 on Copper and Copper Alloys of the A.S.T.M. realized that if it could blaze the way in coordinating specifications in this field, it would not only be helping National Preparedness by obtaining higher quality products, but would also simplify the producer's problems and reduce costs to consumers. Considerable progress, started something over a year ago, has been made already by this committee in coordinating A.S.T.M. specifications with various Government and Federal specifications through meetings in Washington. This trend could be advantageously followed by other committees.

Colored Stainless Steel

The use of colored stainless steel in decorative architectural work is on the increase. Over 5,000 sq. ft. of this type of steel are used in the decoration of New York's recently completed Airlines Terminal at Park Ave. and 42d St. A giant 30-ft. high stainless steel mural crowns the concave entranceway of the 42d St. side of the 6-story building. Stainless steel is used for the walls of the main waiting room. The colors are produced by means of a process developed by Oscar Bach.

Stainless Steel in Aircraft

"Over 2,000,000 lbs. of 18 and 8 stainless steel were used in 1940 by U. S. West Coast aircraft manufacturers alone, chiefly for non-structural parts. An aircraft builder predicts that extended use of stainless steel will be the next great step forward in plane construction, due to its weldability, strength and corrosion resistance."

Machine Tools

Practically the entire output of the nation's vastly expanded machine tool industry is destined for the National Defense Program and the defense of England. According to a survey made by the National Machine Tool Builders' Association, machine tool production, which in 1929 totaled $185,000,000, averaged only $23,500,000 in 1932 and 1933. A slow recovery from the depression brought the volume to $85,000,000 in 1935 and then to $200,000,000 in 1937. It is indicated that the defense production reached $400,000,000 in 1940 with an anticipated output for 1941 of $600,000,000.

Consumption of Steel Scrap

A new record in domestic consumption of American iron and steel scrap was made in 1940—the estimated total is about 41,000,000 gross tons, according to the Institute of Scrap Iron and Steel, Inc. This is an increase of 26 per cent over the 32,434,000 tons melted in 1939, and exceeds the previous high record of 38,006,000 tons in 1937. The world war peak was 26,800,000 tons in 1917. Scrap is more and more a factor in steel production.

(Additional "Trends" on page 246)